GEOMAR REPORT

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Helmholtz-Zentrum für Ozeanforschung Kiel

RV SONNE
Fahrtbericht / Cruise Report
SO242-1

JPI OCEANS Ecological Aspects of Deep-Sea Mining
DISCOL Revisited

Guayaquil - Guayaquil (Equador)
28.07.-25.08.2015

Berichte aus dem GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

Nr. 26 (N. Ser.)

Dezember 2015

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Content

1. Cruise summary

1.1 Cruise summary

Cruise SO242/1 ran from 28 July to 25 August 2015 starting and ending in Guayaquil, Ecuador. In total, 40 scientists from five European countries took part in this cruise of the JPIO project ‚Ecological Aspects of Deep-Sea Mining' to study the ecological long-term impact of deep sea disturbances. The working area, the DISCOL area in the Peru Basin, was ploughed in 1989 and thoroughly studied in the years thereafter, the last cruise, SO106, happened in 1996.

SO242/2 aimed at mapping the DISCOL Experimental Area (DEA) in great detail using ship-based and AUV-based hydroacoustic and optical methods. To see changes between differently disturbed areas and study the possible recovery of the ecosystem, biological sampling occurred with TV-guided multi-coring (MUC), box coring (BC) and epi-benthic sledge tracks (EBS). Additional biological sampling for scavenging animals occurred with baited Amphipod-Traps within and further outside the DEA. For geochemical sampling, multi-, box and gravity coring (BC) was used. Two lander systems equipped with physical sensors such as ADCPs and CTDs were used for current measurements and to monitor sediment plume dispersal created by the EBS. Additional visual studies of the fauna distribution occurred with camera tows (OFOS).

Five main sampling areas were selected, two within the DEA targeting heavily disturbed (ploughed) locations and three reference areas 3 to 4 nmi outside the DEA. All five areas had been sampled in the past and can be directly compared concerning ecological changes. Despite a four-day break due to medical reasons the work program could almost be completed. Four of the working areas were at least sampled with five BCs and MUCs each, and one GC. Box coring could not be performed in the western reference area. In total, 5 CTDs, 27 MUCs, 25 BCs, 7 GCs, 8 EBSs, 5 Amphipod-Traps, 6 lander deployments and 6 OFOS tracks were successfully undertaken and one thermistor mooring was deployed.

In addition, 16 AUV dives clearly showed that plough marks are still well visible after 26 years. There is a slight sediment cover next to the plough tracks, but first analyses of the faunal distribution show that the sessile fauna has not yet recolonised the tracks. Stalked sponges, corals and anemones can be found outside the tracks but still within the DEA. Their distribution patterns inside the DEA do not vary clearly from those on reference sites. The Mn-nodule distribution is not homogenous; there are areas inside the DEA that do not have nodules at the seafloor surface; they are typically linked to depressions that show low backscatter intensity in the AUV side scan sonar data pointing towards less dense sediment infill. In gravity cores, nodules could be recovered even in 9m sediment depth, finding several more or less intact nodules throughout the entire sediment column was common. Water current measurements show slow currents (max. 6cm/s) and a strong tide-influenced current direction, whereas no general direction could be observed. Two 'disturbance experiments' demonstrated that sediment plumes can be monitored using high frequency ADCPs (1200 kHz). The disturbance by the EBS created a sediment plume that stayed close to the seafloor. First analyses of current trajectories showed that the sediment resettled rather quickly. It became clear that plume behaviour during large-scale mining cannot be extrapolated from these small-scale and short-term experiments. In resume, cruise SO242/1 was very successful and research should continue in the DEA area, which is undoubtedly the best studied long-term deep sea disturbance site in the ocean.

1.2 Zusammenfassung

Fahrt SO242/1 vom 28. Juli bis 25. August 2915 begann und endete in Guayaquil, Ecuador. Insgesamt 40 Wissenschaftler aus fünf europäischen Ländern nahmen an der Fahrt des JPIO Projektes „Ecological Aspects of Deep-Sea Mining" teil, um die ökologischen Langzeitauswirkungen

einer Meeresbodenstörung in der Tieefsee zu untersuchen. Das Arbeitsgebiet, das DISCOL Gebiet im Peru-Becken, wurde 1989 mit einem Pflug gestört und anschließend weiderholt untersucht, zuletzt 1996.

Eines der Hauptziele von SO242/1 war es, die DSICOL Experimental Area (DEA) hochgenau mit schiffs- und AUV-basierten hydroakustischen und optischen Methoden zu kartieren. Ein weiteres Hauptziel war es, ökologische Veränderungen in den unterschiedlich stark gestörten Gebieten zu erfassen und deren Wiederbesiedelung zu erkunden. Beprobungen dazu wurden mit dem TV-geführten Multi Corer (MUC), dem Kastengreifer (BC) und dem Epibenthos-Schlitten (EBS) durchgeführt. Weitere biologische Beprobungen erfolgten mittels Amphipodenfallen auch weiter entfernt von der DEA. Zwei Lander-Systeme, ausgestattet mit physikalischen Sensoren wie ADCPs und CTDs, wurden benutzt, um Einsicht in die Strömungsverhältnisse und die Ausbreitung der Sediment-Plumeszu gewinnen, die während EBS-Stationen generiert worden waren. Zusätzliche visuelle Untersuchungen mit dem geschleppten Kamerasystem OFOS gaben weitere Einsicht in die Faunenverbreitung.

Fünf Untersuchungsgebiete wurden innerhalb des DISCOL-Gebietes ausgewählt. Zwei Gebiete liegen innerhalb der DEA in Bereichen, die sehr stark durch das Pflügen gestört worden waren, die drei weiteren sind Referenzgebiete 3 bis 4 nmi entfernt von der DEA. Alle Gebiete wurden bereits in der Vergangenheit beprobt, was einen direkten Vergleich und Aussagen über ökologische Veränderungen erlaubt. Trotz einer viertägigen Unterbrechung aufgrund eines medizinischen Notfalls konnte das Forschungsprogramm fast komplett durchgeführt werden. Vier der fünf Arbeitsgebiete wurden mindestens mit fünf BCs, MUCs und einem GC beprobt. Der Kastengreifer konnte leider im westlichen Referenzgebiet nicht eingesetzt werden. Insgesamt wurden 5 CTDs, 27 MUCs, 25 BCs, 7 GCs, 8 EBSs, 5 Amphipodenfallen, 6 Ländereinsätze und 6 OFOS-Beobachtungen durchgeführt und eine Thermistoren-Mooring verankert.

Zusätzliche 16 AUV-Tauchgänge zeigten eindeutig, dass die Pflugspuren auch nach 26 Jahren noch klar zu sehen sind. Eine leichte Sedimentbedeckung direkt neben den Pflugspuren ist zu erkennen. Erste Analysen der Faunenverbreitung zeigen, dass die sessile Fauna die Pflugspuren noch nicht widerbesiedelt hat. Gestielte Schwämme, Korallen und Anemonen existieren außerhalb der Pflugspuren innerhalb der DEA. Ihre Verteilungsmuster innerhalb der DEA sind denen in den Referenzgebieten sehr ähnlich . Die Mn-Knollenverteilung ist nicht homogen; es gibt Gebiete auch innerhalb der DEA, die keine Mn-Knollen auf der Sedimentoberfläche zeigen. Diese Gebiete sind typischerweise an kleine Depressionen gebunden, die eine niedrige Rückstreustärke in AUV-side-scan sonar-Kartierungen zeigen, was auf einen nur wenig verfestigten Sedimenteintrag hinweist. In Schwereloten konnten mehr oder weniger intakte Mn-Knollen in bis zu 9m Kerntiefe beobachtet werden. Wasserströmungen zeigten niedrige Geschwindigkeiten (max. 6cm/s) und eine deutlich tidenbeeinflusste Strömungsrichtung ohne eine übergeordnete Richtung.

Zwei ‚Störungsexperimente' zeigten, dass Sediment-Plumes sehr gut mit hochfrequenten ADCPs zu erkennen sind. Die durch den EBS erzeugte Sedimentwolke verbreitete sich relativ dicht am Boden. Erste Analysen der Strömungstrajektoren zeigen, dass das suspendierte Sediment recht schnell wieder sedimentierte. Es wurde zudem deutlich, dass das Sediment-Plume-Verhalten während eines industriellen Abbaus nicht aus solchen kleinräumigen, kurzzeitigen Experimenten extrapoliert werden kann. Insgesamt war die Fahrt SO242/1 sehr erfolgreich und die Untersuchungen in der DEA sollten unbedingt fortgeführt werden, da dieses Gebiet das unzweifelhaft am besten untersuchte Langzeitstörungsgebiet in der Tiefsee ist.

1.3 Acknowledgements

We would like to thank the captain and the crew of RV SONNE for the very pleasant, smooth and very work-intensive first leg of SO242. All scientists enjoyed the cruise very much and some of the "novices" that joined a research cruise for the first time are now spoilt. The ship worked extremely smoothly and efficiently, having had professional help on deck made it possible to work full steam around the clock. We further would like to thank all funding agencies that contributed to JPIO allowing scientists from nine institutions to join this important cruise. These are the German BMBF (grants 03F0707A-G), the Dutch NOW-ALW (grants856.14.001 and 856.14.003), the Belgian Science Policy Office (grants BR14/MA/JPI-DEEPSEA1 and BR15/MA/JPI-DEEPSEA2) and EWI Flanders (grant KBO 0248.015.142), and the Portuguese FCT (grant IF/00029/2014/CP1230/CT0002). Further support was provided by the European Union Seventh Framework Programme (FP7/2007-2013) project Managing Impacts of Deep-seAreSource exploitation (MIDAS), grant agreement 603418.

2. Participants

Jens Greinert

During SO242/1 a total of 71 people were on board RV SONNE with 40 scientists and 31 crew members. Scientists and technicians came from 12 different institutes or companies.

Table 2.1. Scientific party during SO242/1

1.	Prof. Dr. Jens Greinert	Fahrtleiter / *Chief Scientist*	GEOMAR
2.	Evangelos Alevizos	PhDHabitatkartierungAkkustik/ *PhD Habitat Mapping Accoustic*	GEOMAR
3.	Meike Dibbern	Labortechnikerin Geochemie / *Lab technicianGeochemistry*	GEOMAR
4.	Jonas Drescher	Stud. HilfskraftGeochemie / *StudentHelperGeochemistry*	GEOMAR
5.	Florian Gausepohl	Wissenschaftler GIS& Datenbank/ *Scientist GIS&database*	GEOMAR
6.	Dr. Matthias Haeckel	Leit. Wissenschaftler Geochemie / *Lead Scientist Geochemistry*	GEOMAR
7.	Dr. Kevin Köser	Wissenschaftler Photogrammetrie / *Scientist Photogrammetry*	GEOMAR
8.	Asmus Petersen	Techniker MUC & GC / *Technician MUC & GC*	GEOMAR
9.	Anne Peukert	Ms.StudentHabitatkartierung / Ms*Student Habitat Mapping*	GEOMAR
10.	Marcel Rothenbeck	Leiter AUV Team / *Leader AUV Team*	GEOMAR
11.	Dr. Timm Schoening	Wissenschaftler Fotodatenbank / *Scientist Image Database*	GEOMAR
12.	Gabriele Schüssler	Technikerin Geochemie/ T*echnicianGeochemistry*	GEOMAR
13.	Anja Steinführer	AUV Team Kartierung / *AUV Team Mapping*	GEOMAR
14.	Lars Triebe	AUV TeamTechniker/ *AUV Team Technician*	GEOMAR
15.	Tim Weiß	Software Techniker AUV & Foto / *Software Technician AUV &Photo*	GEOMAR
16.	EmaunelWenzlaff	AUV TeamTechniker/ *AUV Team Technician*	GEOMAR
17.	CuilingXu	PhD GIS & Datenbank/ *PhD GIS & Database*	GEOMAR
18.	Dr. Gerd Schriever	Biologie & Annotation / *Biology& Annotation*	BIOLAB
19.	Johannes Post	Ozeanographie & Geotechnik / *Oceanography& Geotechnik*	HYDROMOD
20.	Jose N. Gomes Pereira	PhDHabitatkartierung Biologie / *PhD Habitat Mapping Biology*	IMAR

21.	Sophie Paul	PhD Metallgeochemie / *PhDMetalGeochemistry*	JUB
22.	Dr. Inken Preuss	Wissenschaftlerin Metalgeochemie/ *Scientist MetalGeochemistry*	JUB
23.	Tim Jesper Suhrhoff	Stud. Hilfskraft Metalgeochemie / *Student Helper MetalGeochemistry*	JUB
24.	Dr. Henko de Stigter	Wissenschaftler BoBolander&Forams / *ScientisBoBolander&forams*	NIOZ
25.	Erik Simon Lledo	PhDHabitatkartierung Biologie / *PhD Habitat Mapping Biology*	NOCS
26.	Tasmin Yunus Patel	PhDBait-Trap lander / *PhDBait-Trap landery*	RBINS
27.	Dr. Henri Robert	Wissenschaftler Bait-Trap lander / *Scientist Bait-Trap lander*	RBINS
28.	Dr. Nils Brenke	Wissenschaftler Biologie Isopods / *Scientist BiologyIsopods*	SGN
29.	Nicole Gatzemeier	Technikerin DNA Labor / *Technician DNA Lab*	SGN
30.	Karen Jeskulke	Technikerin DNA Labor/ *Technician DNA Lab*	SGN
31.	Dr. Thomas Knebelsberger	Wissenschaftler Biologie Makrofauna/ *Scientist BiologyMacrofauna*	SGN
32.	Prof. Dr. Pedro Martinez	Leit. Wissenschaftler Biologie/ *Lead Scientist Biology*	SGN
33.	Dr. Karin Meißner	Wissenschaftlerin Biologie Polychaeten / *Scientist BiologyPolychaets*	SGN
34.	Sarah Schnurr	PhDDNAUntersuchungen/ *PhD DNA Studies*	SGN
35.	Dr. Ravail Singh	Wissenschaftler Biologie Meiofauna/ *Scientist BiologyMeiofauna*	SGN
36.	Dr. Patricia EsqueteGarrote	Wissenschaftlerin Biology Makrofauna/ *Scientist BiologyMacrofauna*	UAveiro
37.	Dr. Clara Rodrigues	Wissenschaftlerin Biology Makrofauna/ *Scientist Biology Megafauna*	UAveiro
38.	Guy De Smet	Techniker Biologie Meiofauna / *TechnicianBiologyMeiofauna*	UGent
39.	Great Egho	PhD Biology Meiofauna / *PhD Biology Meiofauna*	UGent
40.	BastianDanielBarenbrock	Film / *Film*	Gruppe5

DISCOL REVISITED – SO 242/1 - SCIENTISTS

Figure 2.1: Scientific crew during SO242/1

Table 2.2: Scientific institutes and companies involved

1. BiolabForschungsinstitut, Hohenwestedt, DE | BIOLAB
2. Centre of IMAR of the University of the Azores, Horta, PT | IMAR
3. Deutsches Zentrum für Marine Biodiversitätsforschung, Senckenberg am Meer, Wilhelmshaven, DE | SGN
4. GEOMAR Helmholtz Centre For Ocean Research Kiel, DE | GEOMAR
5. Ghent University, Gent, BE | UGent
6. Gruppe 5 Filmproduktion GmbH, Köln, DE | Gruppe5
7. HYDROMOD Service GmbH, Hannover, DE | HYDROMOD
8. Institut Royal des Sciences Naturelles de Belgique, Brussels, BE | RBINS
9. Jacobs University Bremen GmbH, Bremen, DE | JUB
10. National Oceanography Centre Southampton, Southampton, UK | NOCS
11. Royal Netherlands Institute for Sea Research, Texel, NL | NIOZ
12. Universidade de Aveiro, Aveiro, PT | UAveiro

Table 2.3: Ships crew

1.	Oliver Meyer	Master
2.	Yves-Michael Sossna	Chief Officer
3.	Lars Hoffsommer	2nd Officer
4.	Tim Henning	3rd Officer
5.	Anke Walther	Doctor
6.	Matthias Grossmann	Chief Electr. Engineer
7.	Stefan Meinecke	System Manager
8.	Wolfgang Borchert	System Manager
9.	Achim Schueler	Chief Engineer
10.	Tim Wolfram Stegmann	2nd Engineer
11.	Roman Horsel	2nd Engineer
12.	Hendrik Schmidt	Electrician
13.	Bernd Gustav Heinrich Renken	Electrician
14.	Torsten Bolik	Fitter
15.	Hannes Nanno Betten	MPC / Motorman
16.	Robert Suhr	MPC / Motorman
17.	Georg Hoffmann	MPC / Motorman
18.	Frank Tiemann	1st Cook
19.	Andreas Spieler	2nd Cook
20.	Rene Lemm	1st Steward
21.	Sven Kroeger	2nd Steward
22.	Jan Hoppe	Steward
23.	Luis Royo	Steward
24.	Max Karl Andreas Schrapel	Botswain
25.	Ingo Fricke	MPC / A.B.
26.	Günther Stängl	MPC / A.B.
27.	Reno Ross	MPC / A.B.
28.	Oliver Eidam	MPC / A.B.
29.	Sascha Günter Herbert Fischer	MPC / A.B.
30.	Frank Heibach	MPC / A.B.
31.	Stefan Koch	MPC / A.B.

3. Aims of the cruise

Jens Greinert

Metals such as cobalt, nickel and copper as well as rare earth elements or platinum are globally in great demand. Strategic decisions with regards to metal availability but also with respect to reaching a leading position for deep sea mining technology lately 'revived' studies around deep sea Mn-nodule mining including the question of the environmental impacts of deep sea mining and how they can be assessed and monitored. During the first deep-sea mining boom in the 1970s, industrial nations that conducted exploration cruises claimed potential mining areas and developed mining techniques. Major environmental studies included the US Deep Ocean Mining Environmental Study (DOMES) in the eastern Pacific Ocean and the German Metallifirouse Sediment Atlantis II (MESEDA) program in the Red Sea. Based on the MESEDA results, a new long-term program was developed in 1988 to assess potential environmental impacts from Mn-nodule mining. The DISCOL project (DISturbance and re-COLonization Experiment in a Manganese Nodule Area of the South East Pacific Ocean) and its follow-up project ATESEPP (Impact of potential technical intervention on the deep-sea ecosystem in the southeast Pacific) financed by the German government became the first large-scale benthic impact assessment studies world-wide.

Cruise SO242 aimed to re-study the DISCOL Experimental Area (DEA), in which a plough experiment had been performed during SO61 in 1989 to simulate the impact of Mn-nodule deep sea mining. This area was investigated repeatedly between 1989 and 1997 during several cruises with RV SONNE (SO, 64, 70, 106) to study the impact of a mechanical disturbance of the seafloor and to evaluate the degree of recolonization and recovery of the seep sea environment. The main objective of SO242 was to re-investigate the area for getting another data set in time. With SO242, 26 years after the initial cruise, the DISCOL area is the longest deep sea environment study of a man-made disturbance.

The main objective of the first leg of SO242 was to re-map – both visually and acoustically –and to re-sample the seafloor (inside and outside the plough marks) and the water column for biological, geochemical and oceanographic studies. We employed the latest technology to be able to execute sampling and mapping in as much detail as is possible, which nowadays makes another scale of resolution possible.

The most important objective of the seafloor mapping was to completely map the original DEA area with AUV-based multibeam, sidescan and photo mosaicking in high resolution to ensure detailed insight into the current state of the environment and to acquire well georeferenced data enabling comparisons to data acquired before. The exact locations of the old plough tracks from the initial disturbance in 1989 were of particular interest. Sidescan and multibeam data allowed the AUV to navigate between 7 and 3.5m altitude for subsequent photo surveys with the objective of determining the changes in macro-fauna abundance and plough mark recolonization. Knowing the exact location of plough marks and the impact they still have was a precondition to be able to plan biological and geochemical sampling during SO242/1 and SO242/2 in the best possible manner. Biological samples with video-guided multicorer, box corer, epibenthic sledge and amphipod-traps were taken to investigate the ecosystem recovery compared to the last study in 1996. In addition to taxonomic studies and abundance measurements, the biological samples will also be investigated using state-of-the-art genetic fingerprinting technologies. The distribution of macro-fauna was also investigated during visual OFOS-based stations. Geochemical samples from gravity and multi corer deployments aimed at learning more about the geochemical conditions (in particular oxygen

penetration depth) inside and outside the plough marks and ‘plume’-covered areas and at study changes in comparison to previous analyses from 1996. Oceanographic studies involving lander-based CTD, ADCP and thermistor mooring measurements aimed at better characterizing the physical environment of the deep sea and in particular at deriving data that could be used for a small-scale disturbance experiment using the epi benthic sled as plume-generating tool.

4. Research Plan

Jens Greinert

Cruise SO242 was planned to run in two legs to allow a large range of state-of-the-art technology (AUV, ROV, lander, crawler) as well as classical sampling gear (gravity coring, multi coring, box coring, epi-benthic sledge) to be used on RV SONNE. To accommodate the technical equipment and the needed technical personnel, the cruise was split into two legs. The research plan for SO242/1 aimed to sample some of the areas that have been investigated during previous cruises and generate high resolution bathymetric and optical maps useful for detailed sampling during SO242/2.

It was planned to investigate two reference areas with nodules, one reference area without nodules and two heavily disturbed sites within the DEA. These heavily disturbed areas should have a large area with plough marks allowing to sample within plough marks even with the non-TV-guided box corer. Sampling next to the plough marks should be possible to recover sediment that was impacted by the re-sedimented plume, generated by the ploughing. In each of these five areas it was planned to take five samples each with box corer and multi corer, and recover one gravity core. Additional biological sampling was planned to occur with at least one EBS tow in each of these areas. Five Amphipod-Trap deployments should sample within the DEA, and two times each in 10 and 40km distance from the DEA center.

Two landers were brought to cruise SO242/1 for monitoring currents, acquire physical parameters with CTDs and study the sediment distribution generated by the EBS. One 400m long mooring equipped with 201 thermistors was dedicated to measuring internal turbulences and possible internal wave breaking in the lower 400m of the water column.

One of the overarching tasks was to map the area in very great detail with hydroacoustic and optical methods using the AUV. The aim was to have the AUV in the water for most of the time. As two battery packs exist for AUV Abyss, it was planned to only exchange batteries and the gear if needed and redeploy it as quickly as possible.

Prior to the cruise, no exact positions were selected where the sampling within the DEA should happen as this would necessitate detailed information of the AUV deployments. It was planned to start sampling at the southern reference site, while the AUV was mapping the DEA and both landers acquired physical data from the lower water column. Table 4.1 shows the comparison between the original stations as mentioned in the proposal and the finally undertaken stations. The number of Amphipod Trap deployments was reduced already prior the cruise by the Belgian group.

Table 5.1: Originally planned and finally conducted sampling during SO242/1

Device	Deployments originally planned	Deployments during SO242/1
AUV	11	17 (1 aborted)
CTD	5	5
TV-MUC	25	33 (6 failed)
BC	25	26 (1 failed)
GC	12	7
EBS	15	9 (1 failed)
Amphi-Trap	12	5
MB	1	5 (4 during transit)
LBL	1	1
BoBo-lander	1	2.5 (last lander deployed for SO242/2)
DOS-lander	4.5	3.5 (last lander deployed for SO242/2)
Thermistor mooring	not planned originally	1
OFOS	not planned originally	6
Parasound survey	not planned originally	1

5. Cruise Narrative

Gerd Schriever, Anne Peukert & Jens Greinert

28th July to 7th August: Guayaquil to DEA

The cruise started on 28th July at around 8 am when RV SONNE left the harbor of Guayaquil. All scientists had already embarked the day before and started to set up their labs and get acquainted with the ship. During the transit to the working area the ship-based EM122 multibeam was used to map the seafloor starting just outside the 200nmi zone of Ecuador. Our first station, a CTD deployment, was used to acquire the necessary sound velocity profile and test releasers and MAPRs. After 2 days of transiting, we arrived at the DISCOL Experimental Area (DEA) at noon on 30th of July. Station work started with deploying four Long Base Line Transponder moorings (LBL) for the AUV navigation (stations SO242-1_#3_LBL-1, #5_LBL-2, #9_LBL-3, #10_LBL-4), the two landers DOS (#6_DOS-1) and BoBo (#11_BoBo-1) as well as the 400m long thermistor mooring (#12_Mooring-1) and an Amphipod-Trap (#8_Amphi-Trap-1; Figure 5.1). After triangulating the LBL transponders, the AUV was deployed to map the 78 plough tracks within the DEA using its side scan sonar. While the AUV was surveying, the ship acquired multibeam data which were processed immediately to get a good bathymetric basis for further planning (#17_EM122).

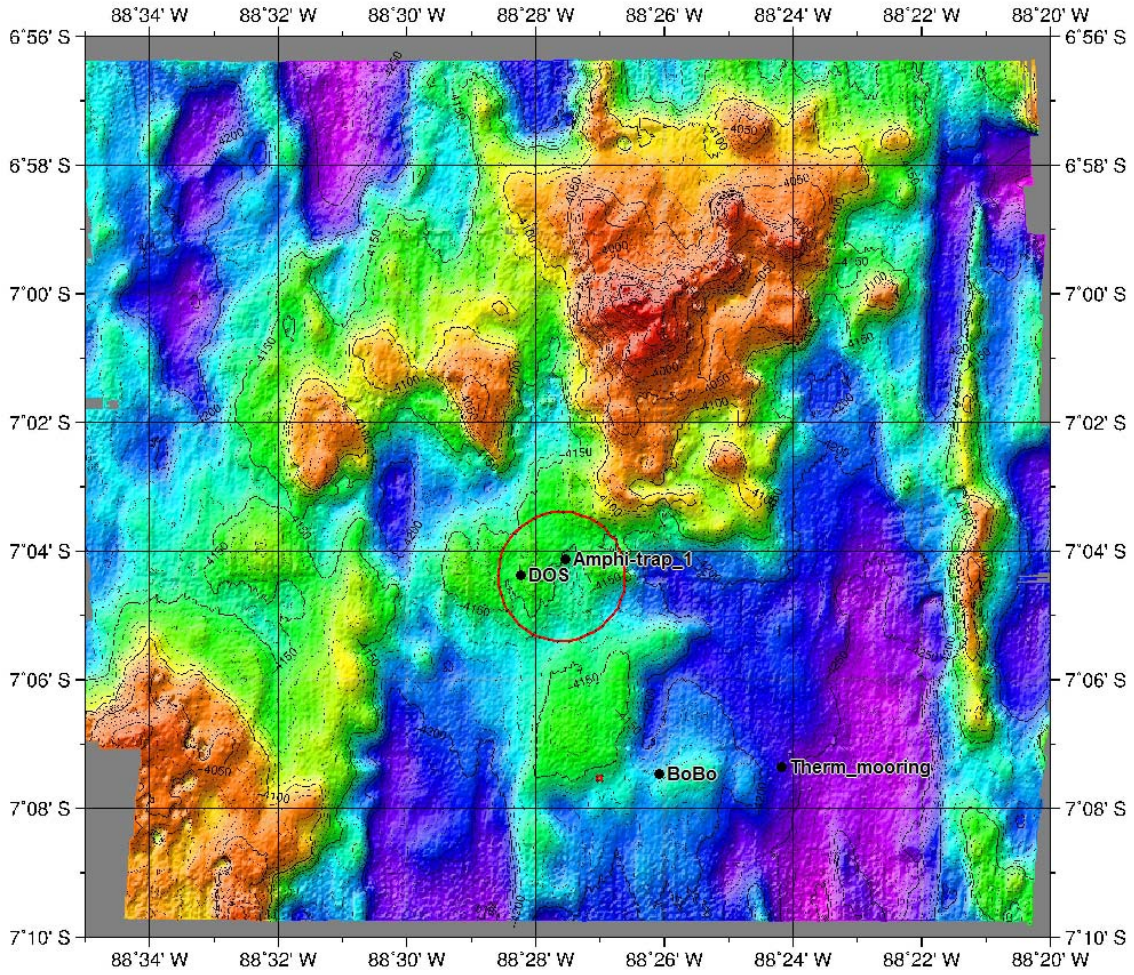


Figure 5.1: Bathymetric map of the DISCOL area with the DEA circle in red and the four deployment sites of the first DOS, BoBo, Amphi-Trap and Thermistor-Mooring deployments. The red square west of the BoBo lander site is the southern reference area.

The DEA appeared not to be as flat as expected from the 1989 drawn contour maps and showed a 30m relief. The new and better equipment presented a better basis for our work than was available 26 years before. After the AUV (called “Tiffy” by its technical crew) was recovered, the side scan data were immediately processed and revealed a complete picture of the plough tracks, which are clearly visible after 26 years, highlighting areas with the densest disturbances. As expected, these were ESE of the DEA center (Figure 5.2).

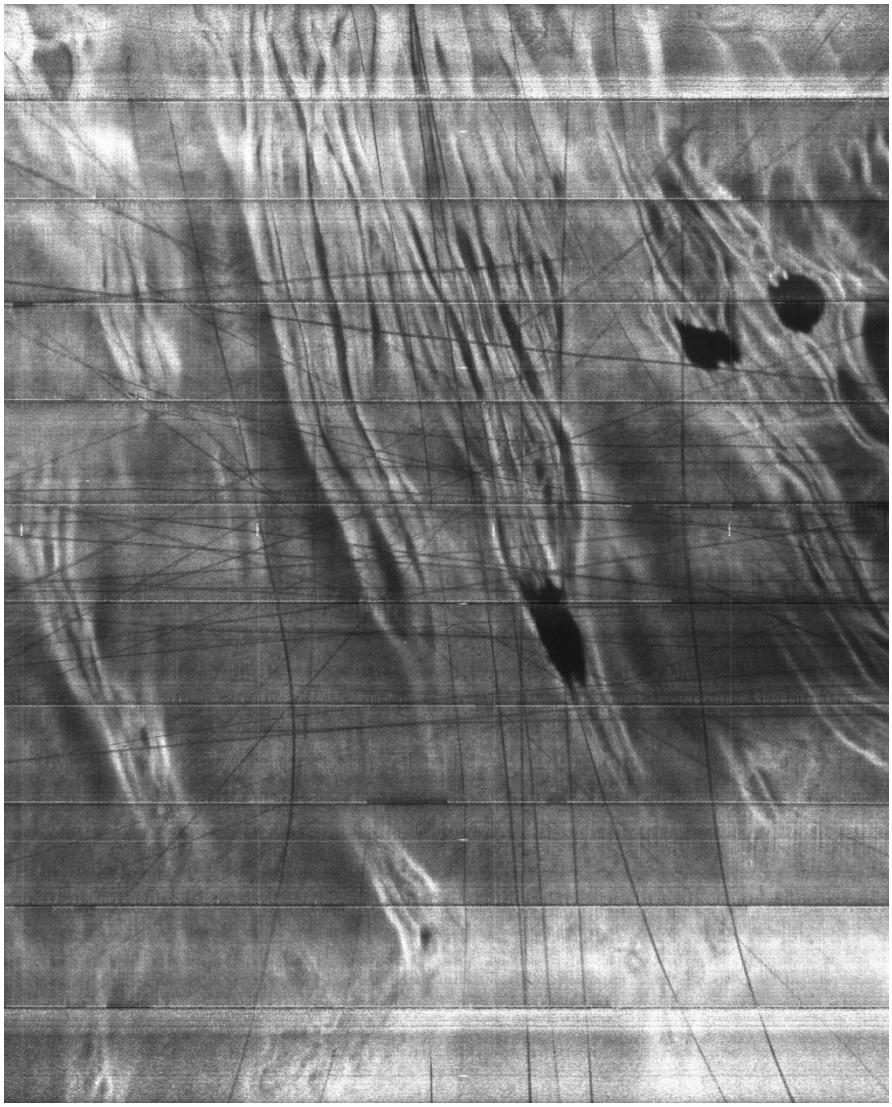


Figure 5.2: AUV sides scan mosaic of the DEA. Black represents low back scatter. The crisscrossing, sometimes curved lines, are plough marks. N-S striking bands of white and black that seem to originate from a ‘black patch’ in the centre are caused by different sediment properties caused by small bathymetric differences.

While the AUV was deployed again for further side scan sonar mapping and camera tests within the DEA, sampling at a reference area 3nmi south of the DEA started. This site was one of the reference sites sampled before. In the assigned 100 x 100m large area five box corers (BC; #20_BC-1; #26_BC-2; #27_BC-3; #31_BC-4; #32-BC-5) and one gravity corer (GC; #38_GC-1) were successfully taken and brought sediments on board for further onboard analyses and sub-sampling for investigations on shore. Taking samples with the TV guided multiple corer (MUC) via the A-frame over the stern of the vessel failed four times due to heave. The fiber optic cable was shifted to the side and MUC sampling became successful. The last of five MUCs in the southern reference site was taken on 5th of August (#46_MUC-11). Additionally to sediment sampling, landers and the Amphi-Trap were recovered and redeployed within the DISCOL area and 2 EBS were towed over the seafloor. Beside few animals the EBS brought the typical large cauliflower-shaped manganese nodules on board. Next to sampling epibenthos at the southern reference site, station #37_EBS- and

#45_EBS-2 were also used for creating a disturbance and monitor the sediment plume distribution with the sensor attached to the BoBo lander (#11_BoBo-1). During the entire time the AUV went into the water for further mapping and camera surveys in the DEA and the southern reference site. The side scan mapping gave important information of the plough mark distribution and allowed to find the best areas for recovering samples from highly disturbed areas inside the DEA.

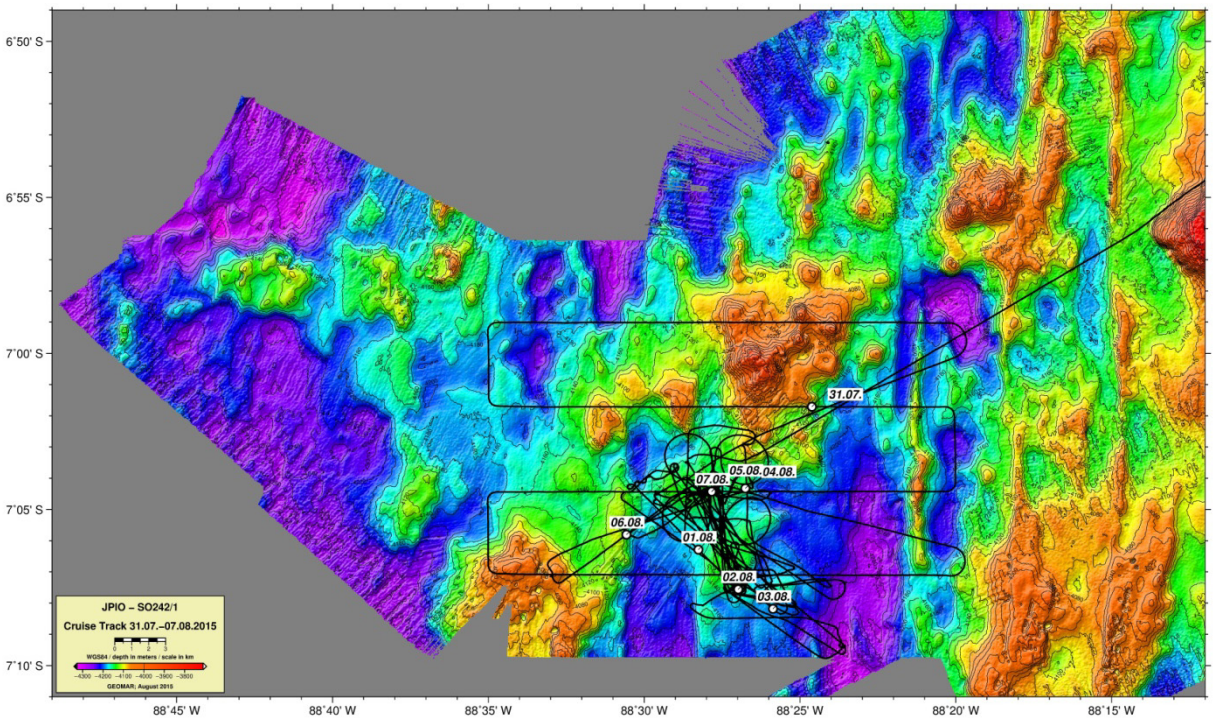


Figure 5.3: Ship track.

On 5th July, we started to sample the second sub-area, the western disturbed area within the DEA. This site had also been sampled during previous cruises. Until 7th July 2015, five more BCs and MUCs were taken, another Amphi-Trap was deployed and the BoBo and DOS landers were both recovered and re-deployed while the AUV continued to photograph and map the DEA. One CTD next to the thermistor mooring (#50_CTD-3) provided hydrographic data of the water column from the surface down to the bottom, but unfortunately the data overwritten and the CTD-cast needed to be re-deployed at the position during SO242/2. Due to the illness of a crew member it was decided to leave the working area on 7th August after the Amphipod-Trap was recovered (#55_Amphi-Trap-3). The resulting tracks run between the southern reference site and the DEA from 31st July to 7th August is shown in Figure 5.3.

8th August to 16th August: DEA to Guayaquil to DEA

The following three days were a break in our scientific program. The time was used to process first data and to add another multibeam line each south and north of the previous transect between DISCOL and Guayaquil.

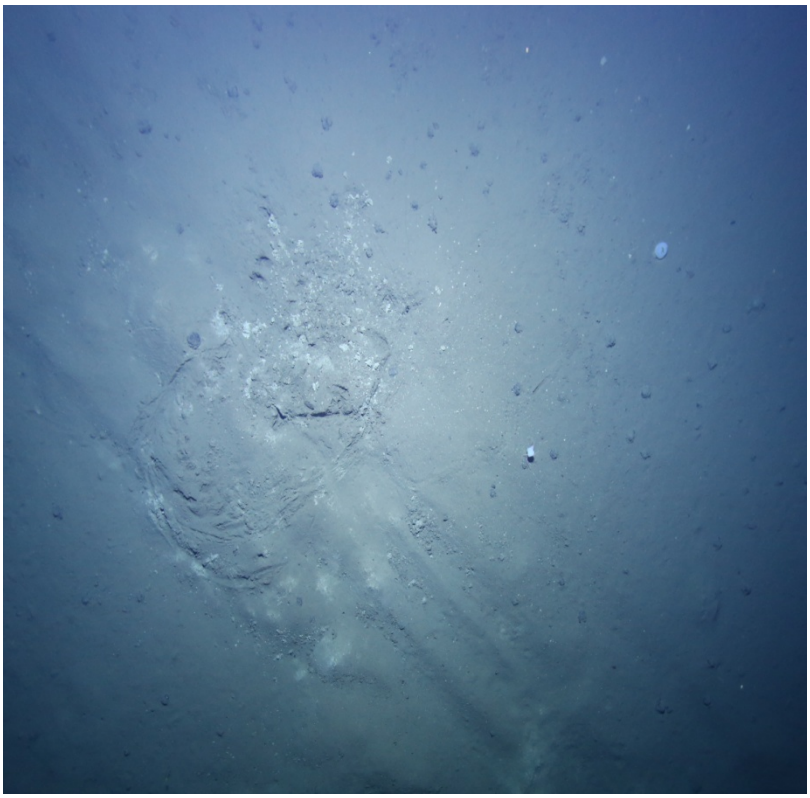


Figure 5.4: MUC sampling site just next to a plough track. Clearly visible are two sponges very close to the track.

We returned to the DEA two hours after midnight on 11th August and the scientific program was continued with the deployment of the fourth Amphipod-Trap 10 nmi NE off the DEA (#68_Amphi-Trap-4). More than 15,000 amphipods were caught during this deployment, which is the largest number of specimens Henri Robert from RBINS (Belgium) had ever caught. Sampling routine very quickly returned . Due to the very good cooperation between the ship's crew and the scientific party we were able to deploy 9 MUCs, 8 Box corers, 5 AUV runs, 3 EBSs and 3 gravity corers successfully during the next four days. After finishing the western, heavily disturbed area inside the DEA, we continued to sample the western reference site 3nmi west of the DEA centre. While the sampling was conducted, the AUV constantly acquired new data giving us more detailed insights into the disturbed area of the DEA. On its photographs we were able to discover imprints of old (from 1996 or even before) and new BC and MUC sampling sites (Figure 5.4).

In addition to sampling, colleagues from Portugal and the UK working on the megafauna deployed our 'improvised' OFOS at the western reference site and in the DEA. They were excited when the video footage showed a greenish holothurians, which probably belongs to a new species or even a new family. Unexpected results were also gained for sediment coring by the geochemists from Kiel and Bremen. The geochemical conditions in the sediment change with depth, oxic sediments become suboxic, which changes the sediment colour from chocolate brown to beige-grey as long as iron is still present as Fe^{3+}. Once this is reduced to Fe^{2+}, the sediment changes colour to a gentle green. Unexpectedly, the core changed colour again within the last 4m of the core that was nearly 10 m long. It became brownish again indicating more oxic conditions. As the cores from this area (all recovered more than 9m sediment) are the longest taken during the cruise, it is still not completely clear where this additional colour change comes from. In between sediment sampling, the EBS was deployed and produced well visible tracks on the seafloor as new disturbances within the SW quadrant of the DEA (#81_EBS-3; #85_EBS-4). Again the EBS was used as 'disturber' with both the BoBo and DOS landers as monitoring tools for the sediment plume. Immediately after station #81_EBS-3, the CTD was deployed to sample sediment-enriched bottom water; unfortunately, no clear sign of increased turbidity could be detected during this station (#82_CTD-5). In strong contrast

to the number of animals found in the Amphipod-Traps, scientists from Wilhelmshaven and Hamburg were quite disappointed at the low number of species and specimens in their nets and hoped to get more material from the upcoming EBS runs. Figure 5.5 shows the track between 11th and 16th August.

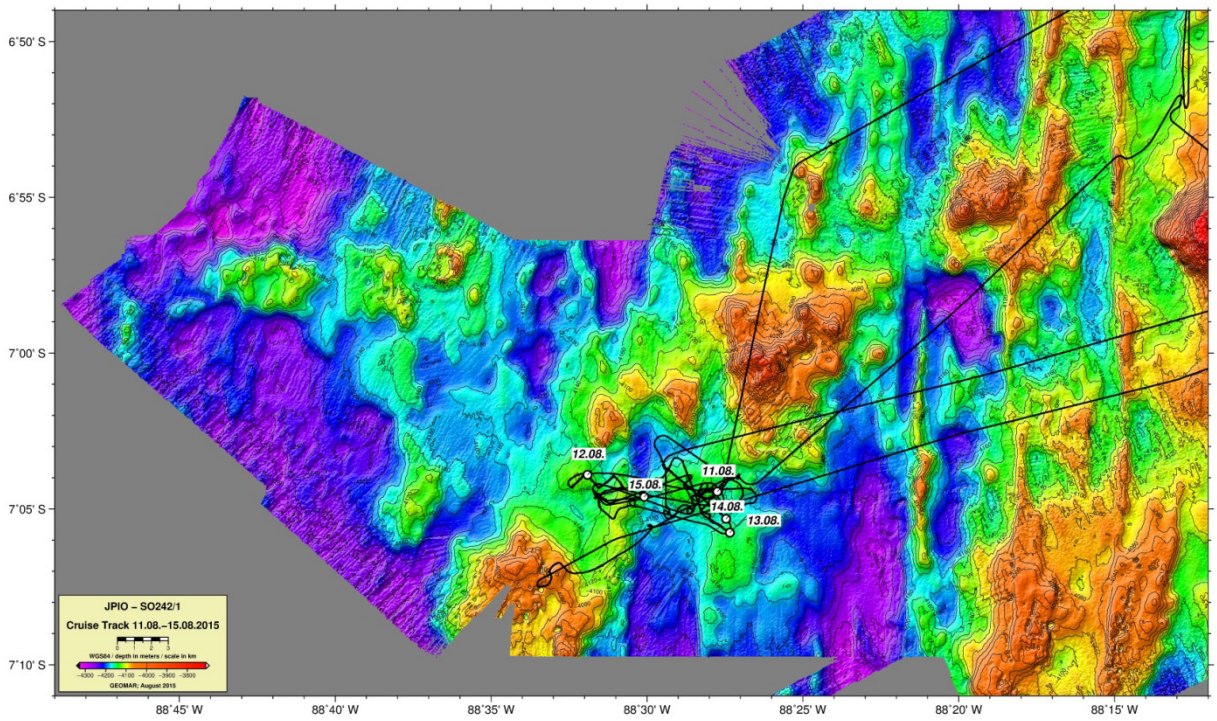


Figure 5.4: Ships track

17th to 25th August 2015

The tight sampling program continued during the last week. The AUV was deployed for five more deployments acquiring multibeam and sub-bottom data of the DEA area and the southern flank of the seamount NE of the DEA. Those maps highlight the volcanic origin of the seamount with some very sharp cliffs and outcrops. After finishing the western reference site, a second heavily disturbed area inside the DEA was sampled followed by a supposedly Mn-nodule free reference site within the trough east of the DEA. Eight video-guided MUCs sampled the seafloor without failure and seven BCs were taken, five of which sampled the plough tracks with the disturbance clearly visible on top of the sediment. The well calibrated side-scan maps of the AUV, the exact navigation by the officers on the bridge and the USBL guidance of the sampling gear made this “blind” sampling so successful. Four additional EBS tows were undertaken sampling SW, N, and SE of the DEA (#104_EBS-7, #122_EBS-8, #126_EBS-9; EBS station #104_EBS-6 failed). Again, only few species and specimens were brought back on board clearly indicating that the epibenthic fauna in the area is less abundant than elsewhere. After sampling all five study sites for geochemical analyses using the GC, the geochemists also recovered sediment from a depression and a small crater at the southern edge of the seamount (#129_BC-26; #132_GC-7). Completing the amphipod sampling, the fifth trap was deployed 40km NW of the DEA centre and was recovered after two days (#106_Amphi-Trap-5). With no more AUV deployments to come, the LBL moorings were scheduled to be taken on board again, but only three could be recovered. The fourth received and acknowledged the release command as it should but did not start rising. The mooring was left to be recovered by the ROV during the next cruise leg. It turned out that the glass flotation spheres had imploded, and using the OFOS with a quickly assembled hook the mooring could be recovered on the consecutive leg So242/2.

For So242/1, the station work finished with two more OFOS tracks taking about 16 hours in total. They provided impressive pictures from the seafloor covered with Mn-nodules and its typical deep

sea fauna but continued outside the DEA towards the Thiel Seamount, where outcrops of pillow basalts showed hard bottom fauna like sponges and sea anemones at current-exposed, steep slopes. When the OFOS was back on board, we started our way back to Guayaquil at 7:30 am on Sunday 23rd August 2015. A last multibeam survey line (#136_EM122) acquired more data towards the south of the previously mapped tracks (Figure 5.5).

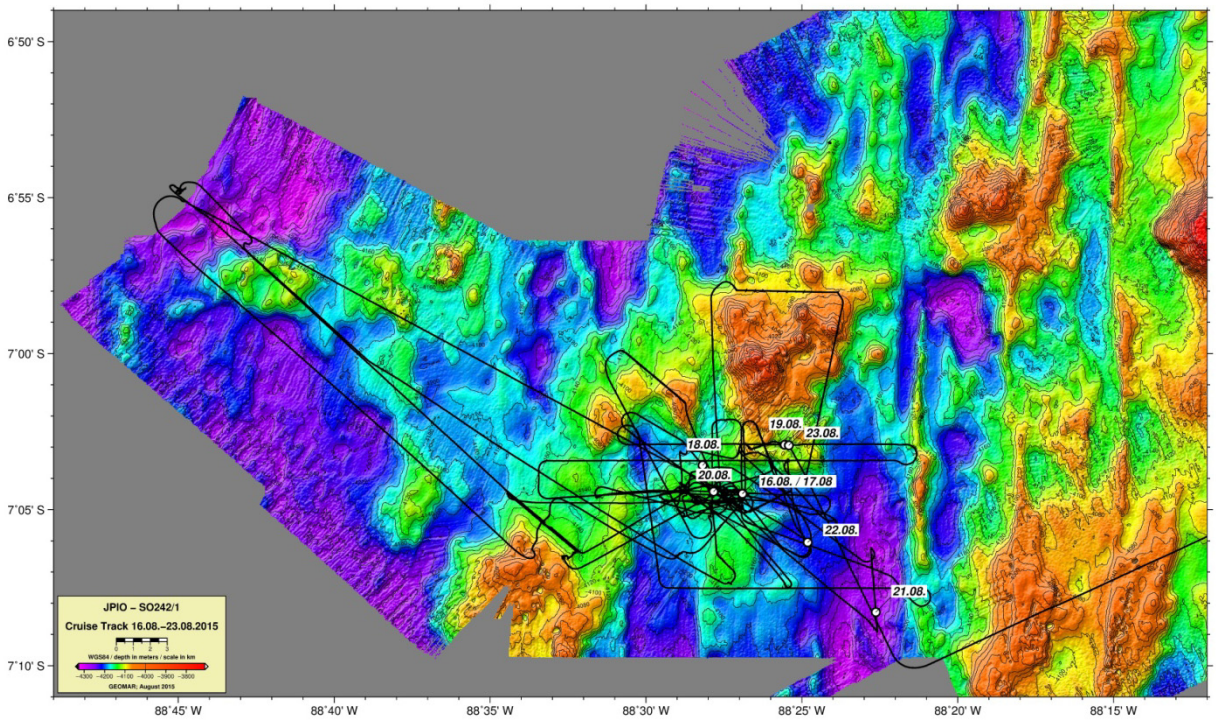


Figure 5.5: Ships track

On 26th August at 9 am, RV SONNE arrived in Guayaquil as scheduled. Scientists and technicians of the next leg were already waiting at the pier to start unloading their containers and for the latest information, new maps and information for their cruise.

6. Working Area

Jens Greinert, EvangelosAlevizos& Anne Peukert

The working area of DISCOL lies 560nmi SW of Guayaquil on the Pacific Oceanic Plate in the Peru Basin (Figure 6.1) in about 4150m water depth. The entire DISCOL area ranges from about 3800m to 4300m water depth

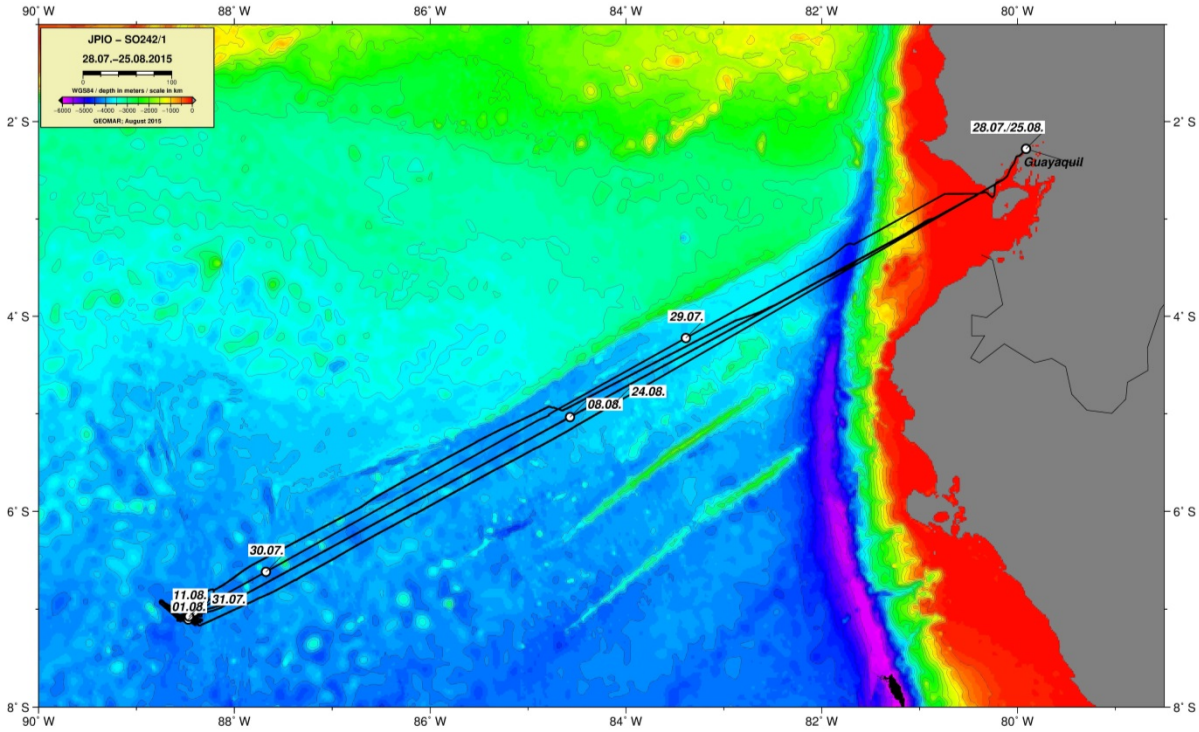


Figure 6.1: Transit lines to and from the working area.

The wider DISCOL area (Figure 6.2) is characterised by N-S oriented graben and horst structures with a deep N-S elongated basin with water depths down to 4300m. An 11 kilometre wide seamount complex NE of the DEA, a second seamount complex to the SW and three higher mounds to the NW clearly show that the DISCOL area is not located in a flat and homogenous deep sea plain. Based on the EM122 bathymetric data the DEA area appears as a relatively smooth, slightly elevated area with a central valley about 30m deep that dips southward (Figure 6.3). When inspecting the AUV-generated bathymetry data more closely, the central part of the DEA area shows a 20m deep valley, the floor of which is comprised by low-relief N-S trending ridges giving the impression of a braided river system. Despite the rich morphological features the DEA area does not contain steep slopes and represents a rather smoothed seafloor.

The wester reference area is located 4nmi west of the DEA center, the eastern and southern reference areas are each 3nmi away. All three reference areas were chosen because they were sampled before. Figures 6.4 to 6.6 show the stations of SO242/1 as well as stations of previous cruises of the reference areas. Reference Area West (Figure 6.6) was only sampled by three MUC and one GC deployment. Box coring was not performed as we found it more important to recover good samples from within the plough marks in the DEA.

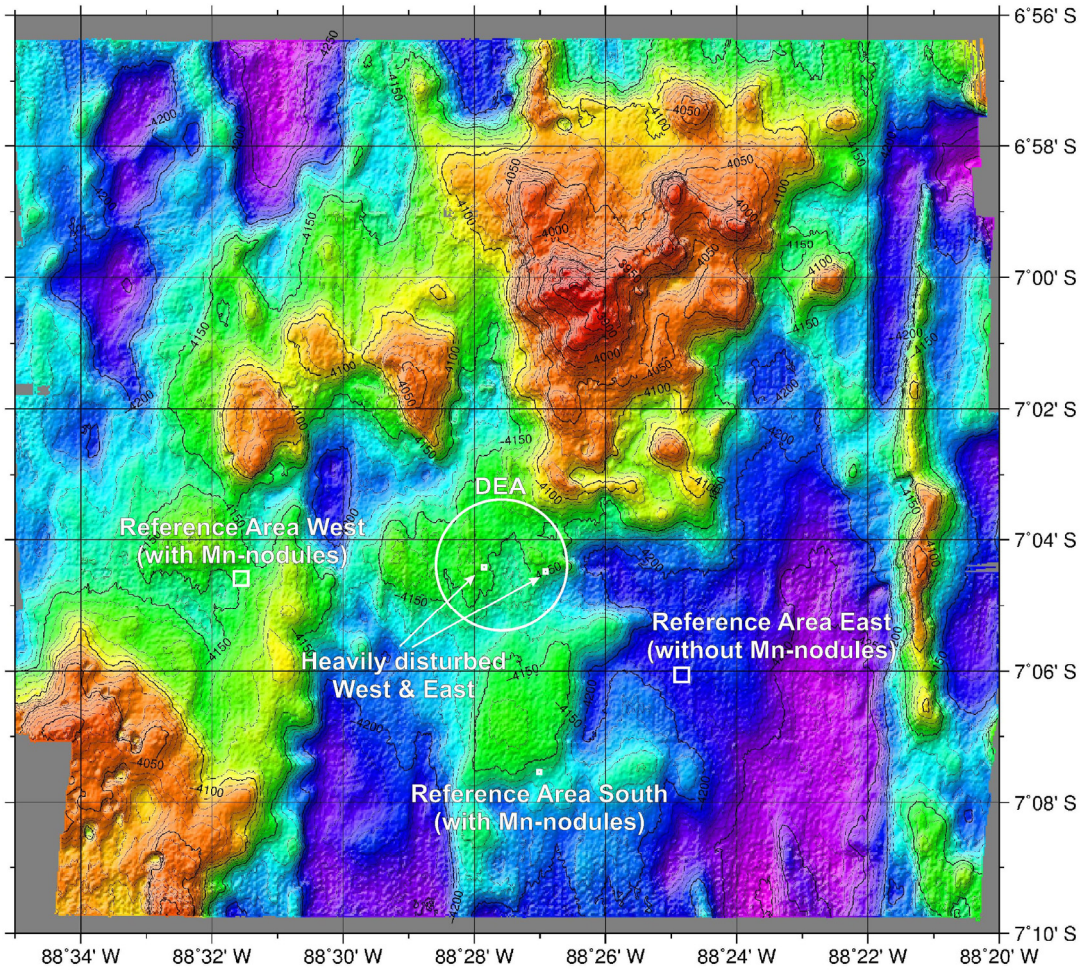


Figure 6.2 Wider DISCOL area with the central DEA and the five sampling areas.

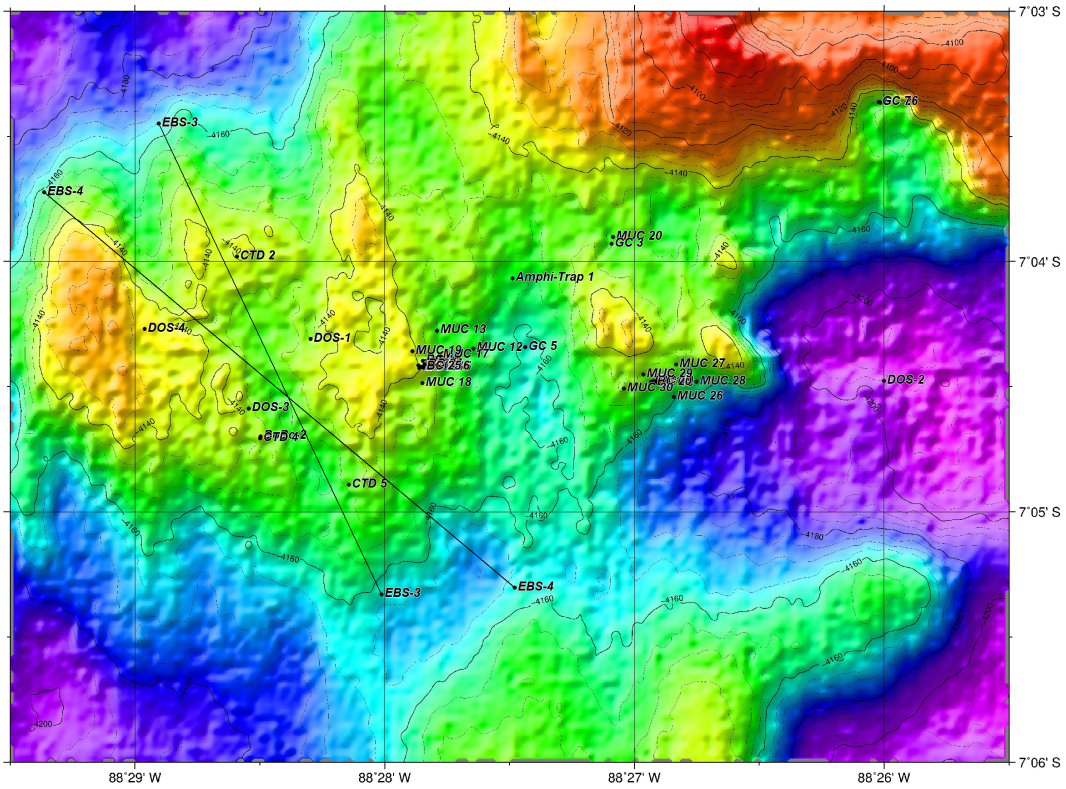


Figure 6.3 Wider DISCOL area with the central DEA and the five sampling areas.

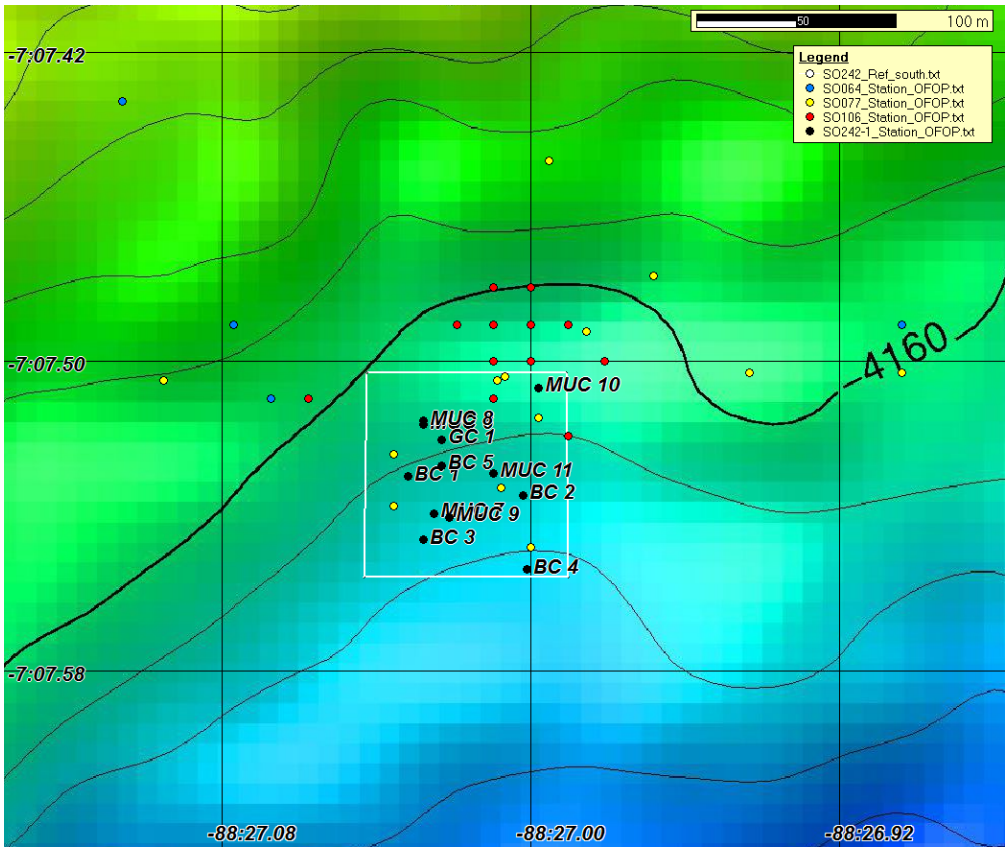


Figure 6.3: Reference Area Southand station locations. Previous sampling sites are indicated by red (SO106), yellow (SO77) and blue (SO64) dots.

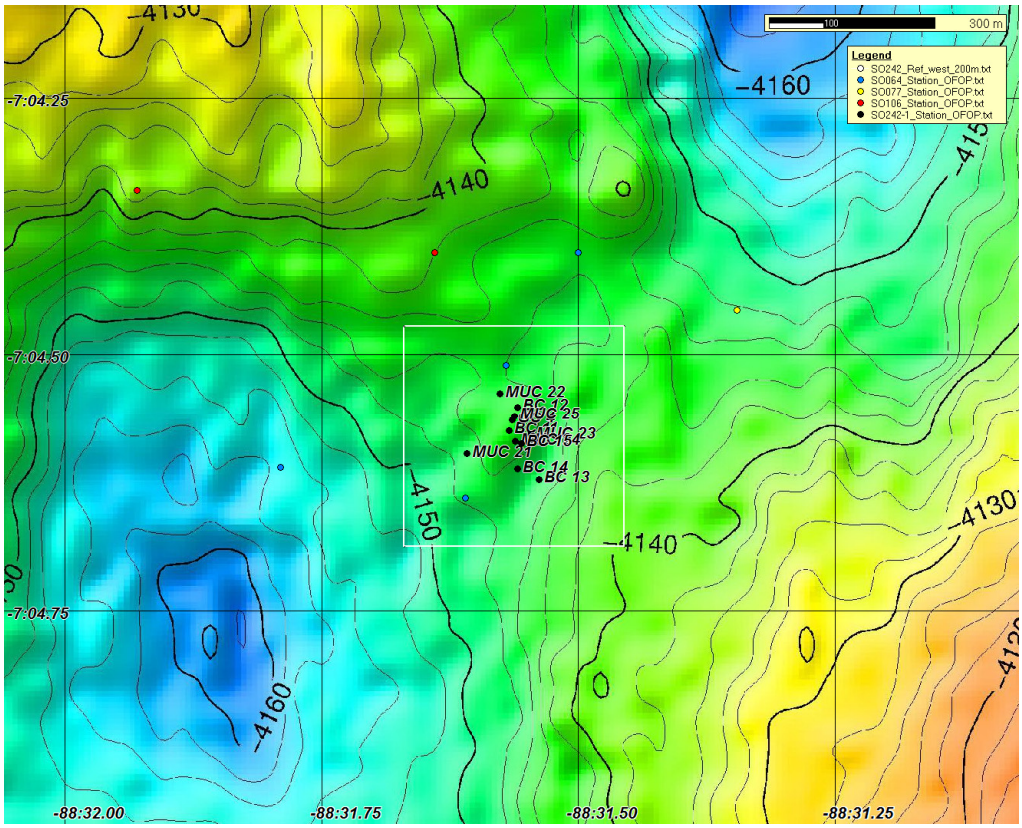


Figure 6.4: Reference Area Westand station locations. Previous sampling sites are indicated by red (SO106), yellow (SO77) and blue (SO64) dots; earlier sampling was rather scattered in this reference area.

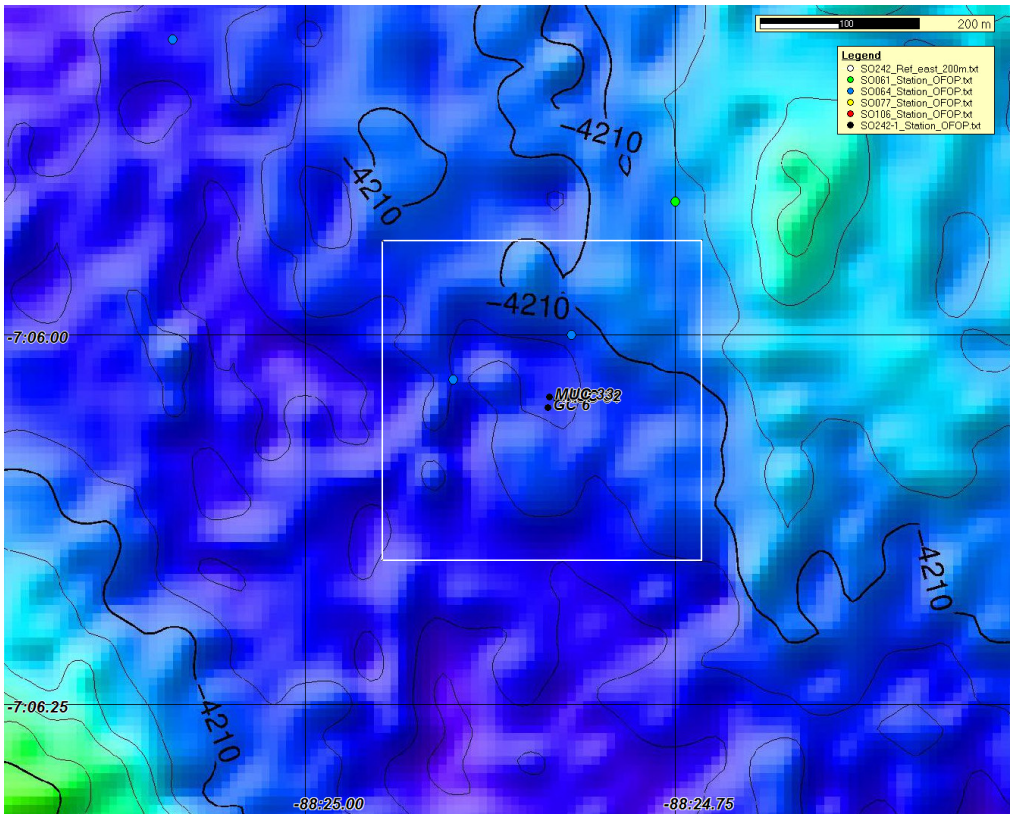


Figure 6.5: Reference Area East and station locations. Previous sampling sites are indicated by blue (SO64) and green (SO61) dots.

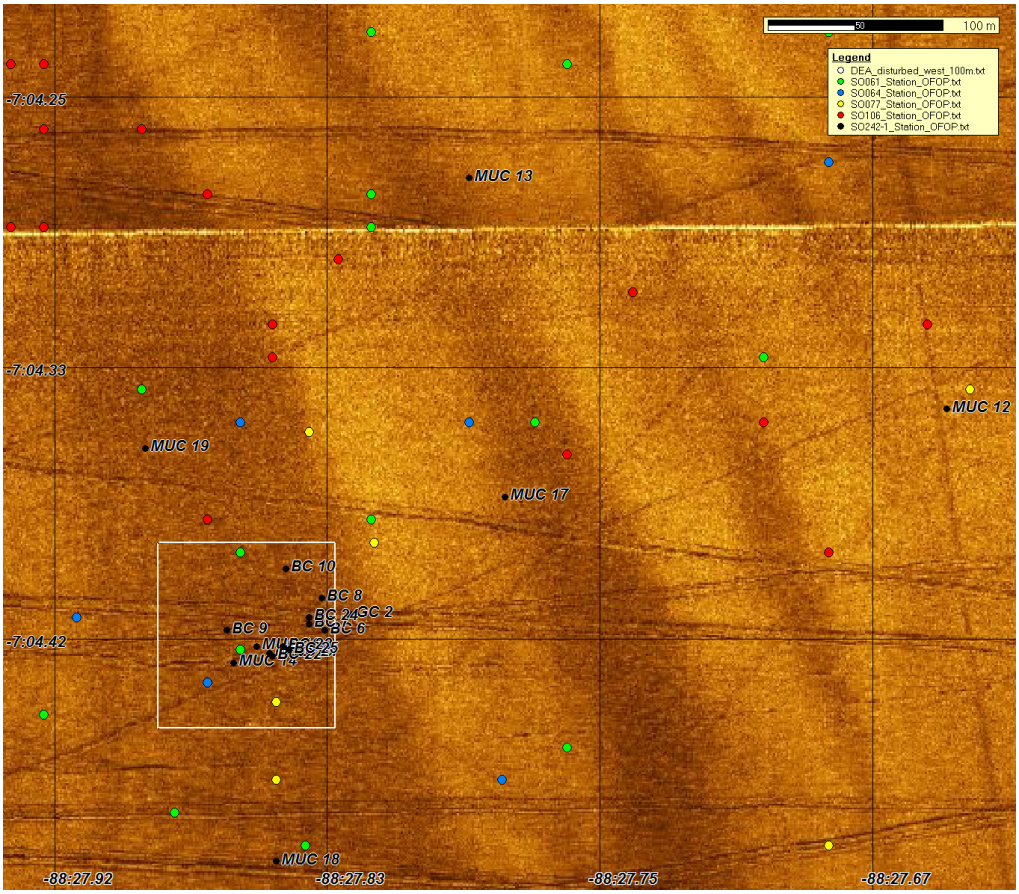


Figure 6.6: Heavily disturbed area west inside the DEA.Background map shows the sidescan data of the AUV. Previous sampling sites are indicated as coloreddots.

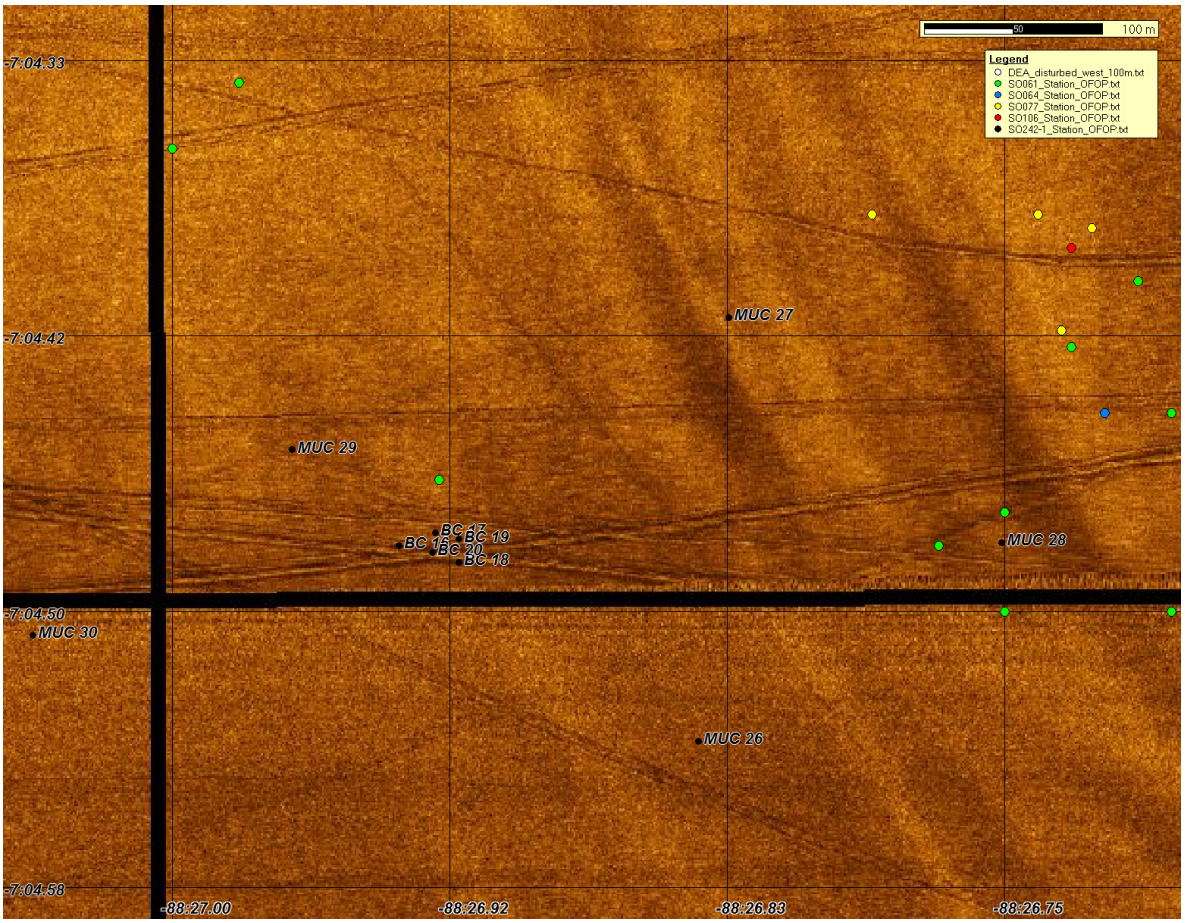


Figure 6.6: Heavily disturbed area east inside the DEA.Background map shows the sidescan data of the AUV. Previous sampling sites are indicated as colored dots.

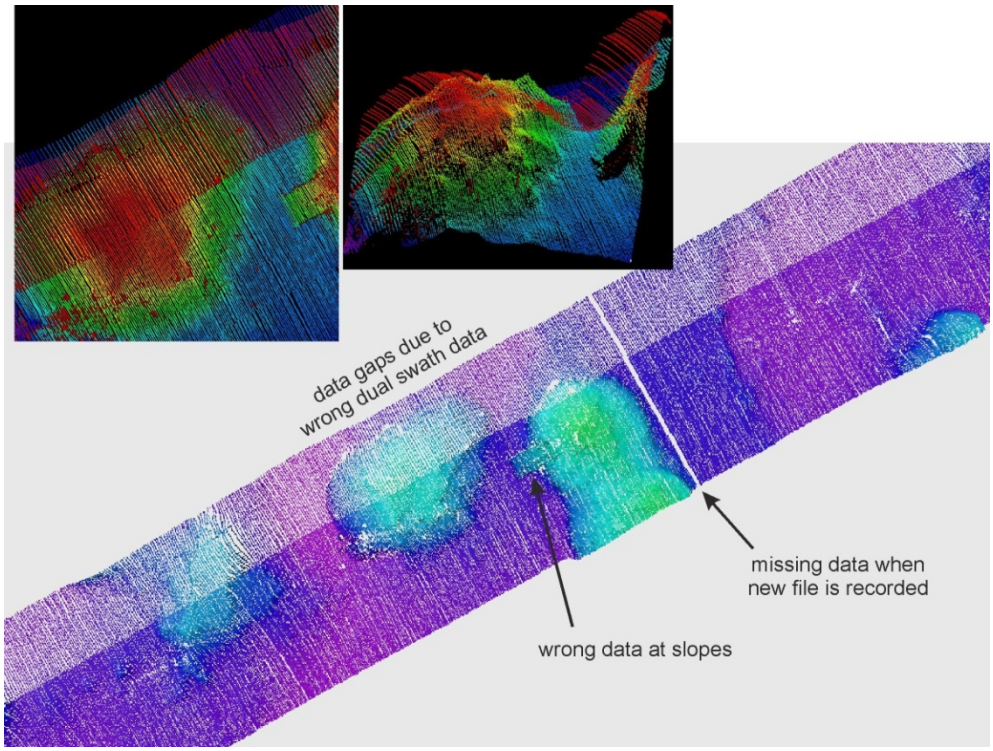
7. Methodologies

7.1. Ship-based hydroacoustic mapping (EM122 & Parasound)

Jens Greinert & Anne Peukert

The EM122 is a 12kHz multibeam system with 432 beams each having 1° along track and 0.5° across track beam angles. During SO242/1 the system was recording during transit time between the working areas and one dedicated multibeam surveys for mapping the wider DISCOL area. Data are stored in the common Kongsberg .all file format. Motion data and static offset correction is done by a Seapath MRU-GPS system that directly feeds into the EM122 electronic. Sound velocity profiles from CTD casts have been uploaded into the system upon arrival at a new working area. Survey speed during transit was 12 to 15kn. For dedicated surveys in the working areas the speed was reduced to 8kn for getting higher data density along track. The swath width during transit was set to 130° (65° starboard and portside) and has been restricted to 17km swath width. With wider swath width, the outer sections become rather noisy. Data processing was performed with Fledermaus for data cleaning and export of xyz data. The exported xyz data were gridded and plotted using GMT 5.1.1. The nearneighbor command was used as gridding algorithms, cell sizes varied from 100 to 30m depending on water depth and data quality. Results of the ship-based multibeam mapping are shown throughout the cruise report; the complete data set is shown in Figure 7.1.2

During transits we encountered a strange behavior of the system during the first survey line from Guayaquil to the DISCOL area. In the starboard outer sector every second ping during dual-swath mode gave wrong values. This caused that the outer sector had much less data points decreasing resolution (Figure 7.1.1). This behavior changed after the complete system with all support sensors was switched off and on again. Although this solved the problem about 30min of data were lost. While mapping the deep sea from outside the EEZ of Ecuador and the working area, many seamounts where mapped. During several crossings of seamounts wrong data showed a second seafloor at steep slopes, manly in the centre parts of the swath. Such false data have been already observed during SO239.



7.1.1: Wrong and as false flagged data of one of the dual-swaths in the starboard outer sub-fan.

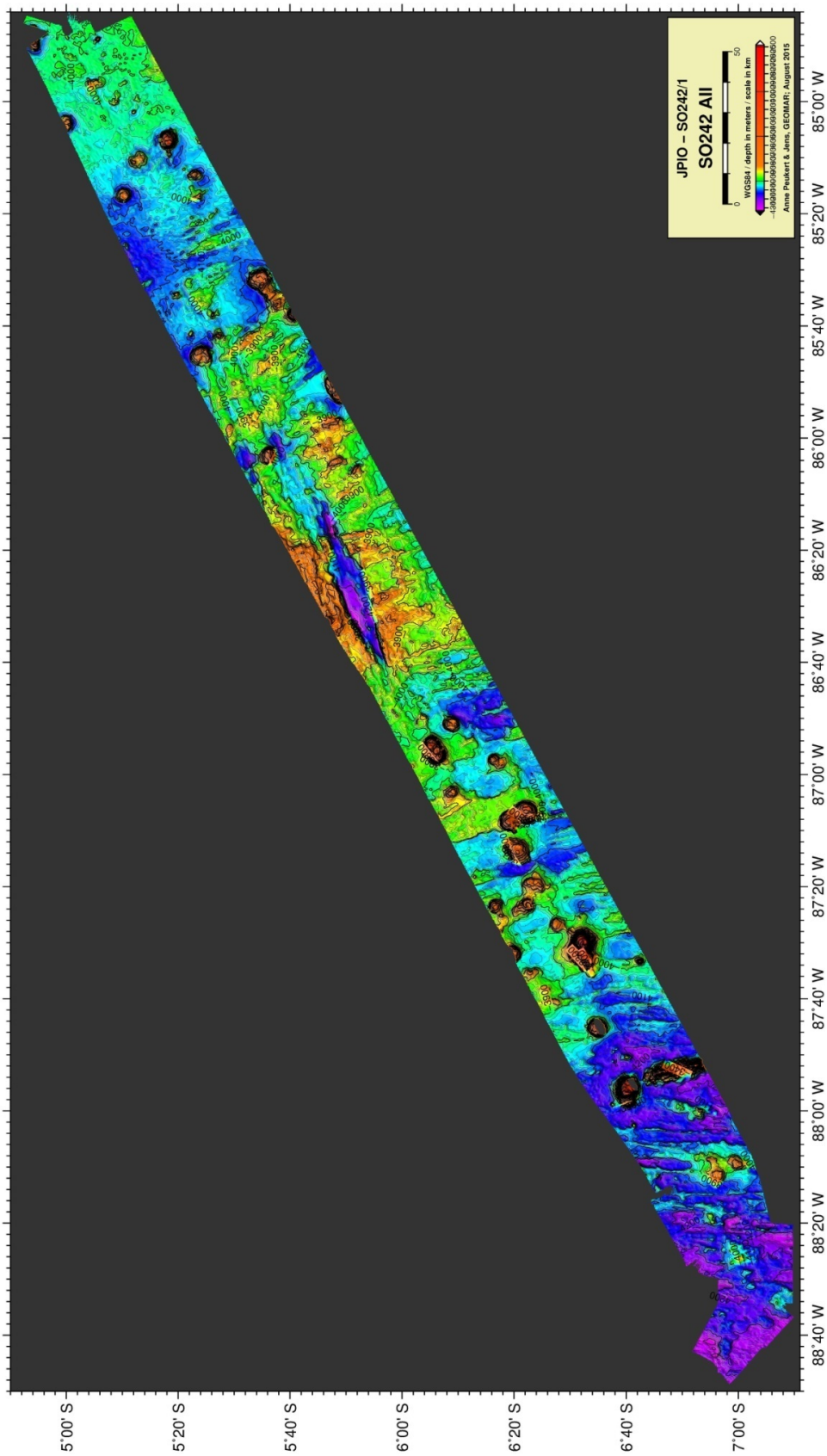


Figure 7.1.2: Complete area mapped during SO242/1

One Parasound survey was conducted during SO242/1 (station #116_P70). Data were preliminary processed to confirm sediment coverage in the planned sampling sites in the seamount area and to investigate if the sediment thickness is greater in the non-nodule trough area east of the DEA.

7.2. CTD & water sampling

Inken Preuss, Johannes Post, Sophie Paul, Tim Jesper Suhrhoff

During SO242/1 we used the ships CTD for mainly acquiring sound velocity data but also to record physical water column properties to be linked to the temperature information of the Thermistor mooring. The CTD used was a SeaBird 911 with additional sensors and water sampling carousel (24 10l Niskin bottles; Figure 7.2.1). Data were recorded with the SeaSave software. GPS data (ships location) was stored in the archived data. In total five stations were sampled.

Figure 7.2.1: The Sea Bird SBE 32 carrousel water sampler with the SBE 911 plus CTD profiler

For one CTD (SO242/1_#58_CTD-4) water samples for geochemical analyses were taken in order to get background values of the water column. Niskin bottles were closed in 12 depths and subsamples taken for amino acids and N-isotope, DOC, Mn(II/III) speciation and trace metal – including REY – analyses. All samples except for the amino acids and N-isotopes were filtered through 0.2µm cellulose-acetate filters. Mn(II/III) speciation as well as amino acid samples were stored at -20°C, whereas samples for DOC and trace metal analyses were acidified to pH 2 and kept refrigerated.

For comparison reasons a small, low cost and high resolution CTD48 M memory probe from Sea & Sun Technology, Germany was attached to the SBE 9 plus CTD for the vertical profiling and to the BoBo – Lander for time series recording and comparison with SBE CTD time series data at the sea floor. The CTD48 M is a 4 channel probe for oceanographic measurements of conductivity, temperature, pressure and one optional parameter for measurements down to 6000 m water depth. The memory probe used for this survey runs from an internal battery and records data at programmable time intervals or pressure stamps in a FLASH memory with a capacity of 8 Mbytes. Up to 400.000 CTD data sets can be recorded and stored. The sensors listed in Table 7.2.1 were present at the memory CTD.

Table 7.2.1: Sensors and sensors accuracy and resolution used in the CTD48M

Sensors	Range	Accuracy	Resolution	Response time
Conductivity	0 – 70 mS/cm	+/- 0,003 mS/cm	0,001 mS/cm	150 ms
Temperature	-2 - +36 °C	+/- 0,002 °C	0,001 °C	150 ms
Pressure	6.000 dbar	+/- 0,1 % full scale	0,002 % full scale	150 ms

7.3 MAPR measurements

Cuiling Xu, Tim Weiß, Jens Greinert

Throughout SO242/1 we attached MAPRs (Miniature Autonomous Plume Recorders) directly to different gear or on the wire 40 to 50m above the gear. The idea was to get as many temperature recordings as possible to see temporal variability during the cruise and acquire a comprehensive data set for water turbidity close to the seafloor.

Figure 7.3.1: MAPRs being attached to the wire, fixed to the EBS (top right) or the mooring rope of the LBL transponders just before deployment.

The MAPR is a CTD type device equipped with a pressure and temperature sensor as well as an light backscatter sensor (LBSS) and oxygen reduction potential sensor (ORP). Four of such sensors were used during the cruise; they were rented from NOAA, who kindly supported those sensors on very short notice. Figure 7.3.1 shows the mapper attached to the cable and the EBS before deployment, they were attached to GC, MUC, BC, EBS, OFOS deployments as well as the LBL moorings used for AUV underwater navigation. The fastest sampling interval of the MAPR is 5 seconds, this was chosen during most of the deployments, the sample interval was extended to 60 seconds for the LBL deployments. On the LBL moorings, the MAPR were placed ca. 15m above the bottom.
Data were converted from raw sensor readings to depth (m), temperature (°C) and voltage levels for LBSS (V) and OPR (mV) and stored as simple ascii files; date and time information, Julian day as well as the position of the deployment were added. A total of 76 MAPR deployments have been recorded and will be accessible via the JPIO data base.

7.4 BoBo, DOS lander and thermistor mooring

Jens Greinert, Henko de Stigter, Hans van Haren, Tim Weiß & Timm Schoening

One thermistor mooring and two landers (DOS, BoBo) were deployed during SO241/1 nearby and within the DEA. The DOS and BoBo lander were deployed at the end of SO242/1 and will be recovered at the end of SO242/2.

Thermistor mooring

The thermistor mooring of NIOZ is equipped with 201 NIOZ-4 thermistors and three AquaDopp acoustic current meters. The layout of the mooring is shown in Figure 7.4.1. The NIOZ-4 self-contained temperature (T) sensors are used sampling at 2 Hz, with precision better than 0.001°C and a noise level of about 6×10^{-5}°C. NIOZ-4 is an upgrade of NIOZ-3 (van Haren et al., 2009; van Haren and Gostiaux, 2010), with similar characteristics, except that it is 2/3 smaller and has a reduced power consumption (with the capacity of sampling at a rate of 2 Hz for the duration of 1 year). Sensors were taped at 2.0 m vertical intervals to a nylon-coated steel cable, with the lowest sensor 6 m above the bottom and the upper one 406m above the bottom The sensors are synchronized via induction every 6 hours. Thus, timing mismatch is less than 0.04 s. A special steel drum was used in the ship's own mobile winch for deployment over the stern. The deployment on 30 July 2015, without additional block, went smooth and successfully. The position of the mooring on the seabed was subsequently determined by ranging the IXSEA acoustic releasers from three different positions around the deployment position. The Thermistor mooring was deployed once (SO242/1_#12_Mooring-1) to be recovered at the end of SO242/2.

Figure 7.4.1: Thermistor mooring on its drum ready for deployment (left) and NIOZ-4 thermistors (right)

BoBo lander

The BoBo (Bottom Boundary Layer) lander of NIOZ, a 4-m high, long-legged tripod lander, was specifically designed to study currents and sediment transport near the seabed(Van Weering et al.,2000). Current profiles in the lower 2 m above bottom are measured with an RDI 1200 kHz ADCP mounted downward-facing at 2 m above bottom in the centre of the lander frame, whilst an upward-facing RDI 300 kHz ADCP mounted in the top of the frame records current profiles in the water up to several tens of metres above the lander. The lander is further equipped with a Seabird 16plusCT,a WetLabs ECO-FLNTURTD, and a Technicap PPS4/3 sediment trap. Two Benthos releasers keep three

weights in place until release, and a flash, radio beacon and a Xeos Iridium Sat + GPS beacon are added for localization after surfacing. The BoBo lander is usually deployed in freefall mode.

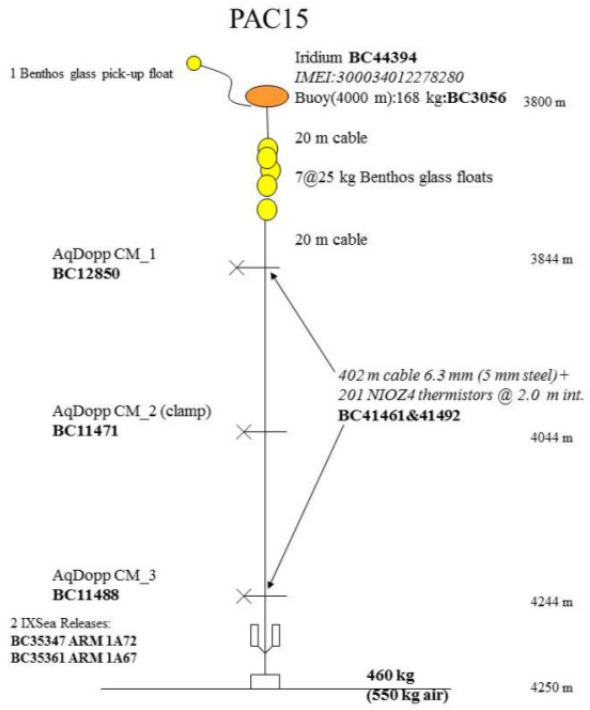


Figure 7.4.2: Images of the mooring on deck before deployment and scheme of the deployment layout.

During SO242/1 the lander was deployed two times for short duration of 5 and 10 days, respectively, first in the undisturbed area three miles south of the DEA and then in the disturbed area near the centre of the DEA. During both short deployments, a resuspension experiment was carried out in which the lander served for recording a sediment plume generated by towing the epibenthic sled (EBS) at relatively short distance along the lander. After this, the lander was once more deployed in the undisturbed area south of the DEA, from where it will be recovered in late September during SO242/2.

Figure 7.4.3: BoBo lander.

During all three deployments, the two ADCP's were set to record at 5 minute intervals. Since the lander's own Seabird 16plus CT was malfunctioning, it was replaced, together with the WetLabs ECO-FLNTURTD connected to it, with a Seabird 19 CTD and SeaPoint optical backscatter (OBS) sensor supplied by RBINS (L. Naudts). The CTD was set to record at 5 minute intervals. In addition, a Sea&Sun CT supplied by Sea&Sun (J. Post) was added during the first short deployment, with sampling rate of 0.5 minute. The sediment trap was only used on the last, longer deployment, with a sampling rate set at 4 days. The sediment trap bottles were filled with bottom water to which no chemical preservative was added. Following deployment, the position of the BoBo lander on the seabed was determined by ranging the Benthos acoustic releasers from three different positions around the deployment position.

DOS Lander

The Deep-Sea Observation System (DOS) lander from GEOMAR is based on a multipurpose platform (Pfannkuche and Linke, 2003) and equipped with an RDI 300kHz upward looking ADCP, a KUM sediment trap with max 21 bottles, a Seabird 16plus CTD with Wetlabs ECO-FLNTURTD, and an Ocean Imaging Systems stereographic camera system. One IXSEA releaser keeps three weights in place until release. A flash, radio beacon and ARGOS transmitter are attached for localization after surfacing of the lander. The lander was deployed in freefall mode but can be also launched in a TV-guided mode.

Figure 7.4.4: The DOS lander and the stereographic camera system that did not work during SO242/1.

7.5 Autonomous Underwater Vehicle

Marcel Rothenbeck, Anja Steinführer, Lars Triebe, Emanuel Wenzlaff

The Autonomous Underwater Vehicle (AUV) Abyss (built by HYDROID Inc.) from GEOMAR can be operated in water depths up to 6000 m. The system comprises the AUV itself, a control and workshop container, and a mobile Launch and Recovery System (LARS) with a deployment frame that was installed at the starboard side on the afterdeck of RV SONNE. The self-contained LARS was developed by WHOI to support ship-based operations so that no Zodiac or crane is required for launch and recovery. The LARS is mounted on steel plates, which are screwed to the deck of the ship. The LARS is configured in a way that the AUV can be deployed over the stern or port/starboard side of the German medium and ocean-going research vessels. The AUV Abyss can be launched and recovered at weather conditions with a swell up to 2.5 m and wind speeds of up to 6 Beaufort. For the recovery the nose float pops off when triggered through an acoustic command. The float and the ca. 19 m recovery line drift away from the vehicle so that a grapnel hook can snag the line. The line is then connected to the LARS winch, and the vehicle is pulled up. Finally, the AUV is brought up on deck and secured in the LARS.

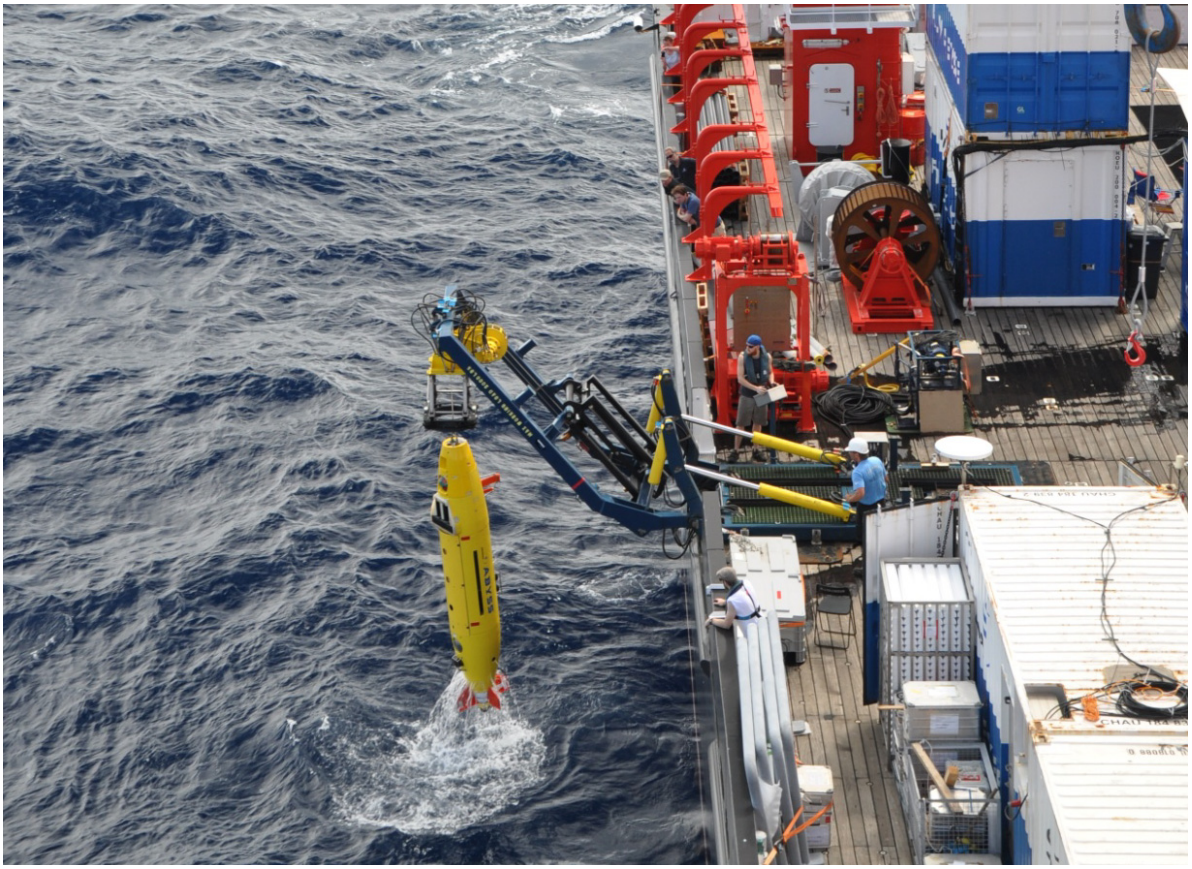


Figure 7.5.1: Launch and Recovery System in use while recovering AUV (Photo: Inken Preuss)

The AUV Abyss is equipped with an Edgetech Sisescan Sonar (120/410 kHz), a Seabird FastCAT SBE 49 CTD and a Wetlab FLNTU turbidity and Fluorescence sensor. The RESON Seabat 7125 multibeam (200/400 kHz), the camera system 2K15 (developed at GEOMAR) and the Edgetech Sub-bottom Profiler are exchangeable. During cruise SO242-1 17 missions were flown by Abyss. The missions were flown using the multibeam, camera and sub-bottom profiler configuration.

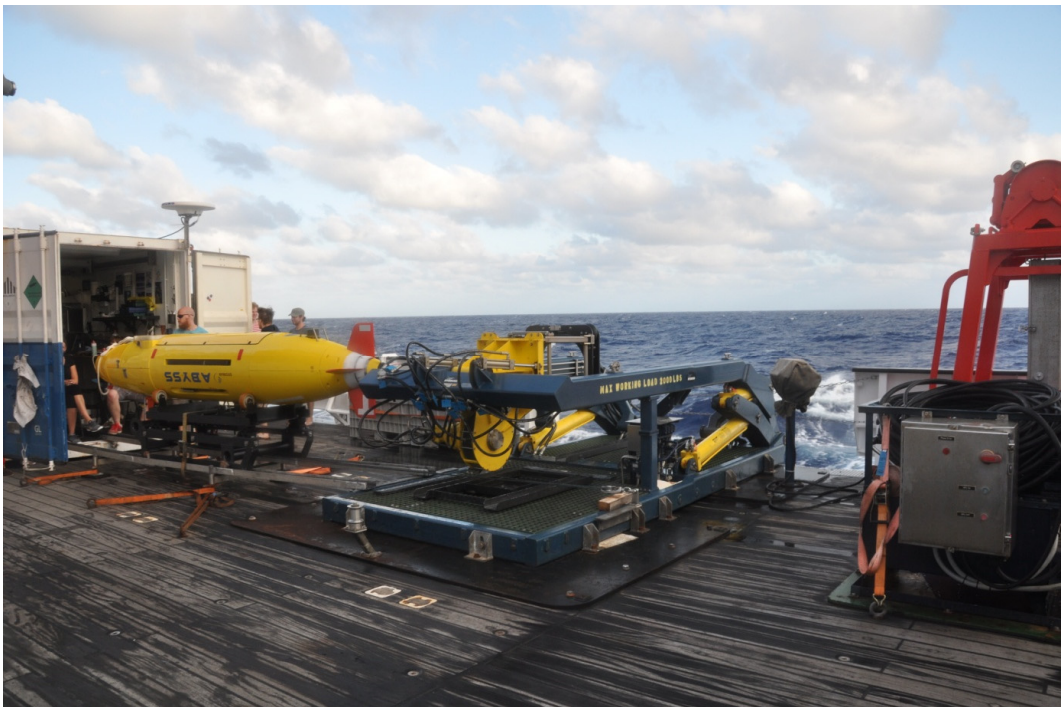


Figure 7.5.2 AUV system composition on board Sonne during SO242-1 (Photo: Inken Preuss)

Bathymetry

A multibeam calibration was performed by sailing particular patterns to find the mounting angle errors (roll, pitch and heading). Roll: two lines over a flat area in opposite directions with same speed. Pitch: two lines over an area with slopes in opposite directions with same speed. Heading: two lines over an area with slopes, the lines need to overlap half a swath width, in same direction with same speed. The mounting offsets were calculated using QINSy / Qimera (QPS).

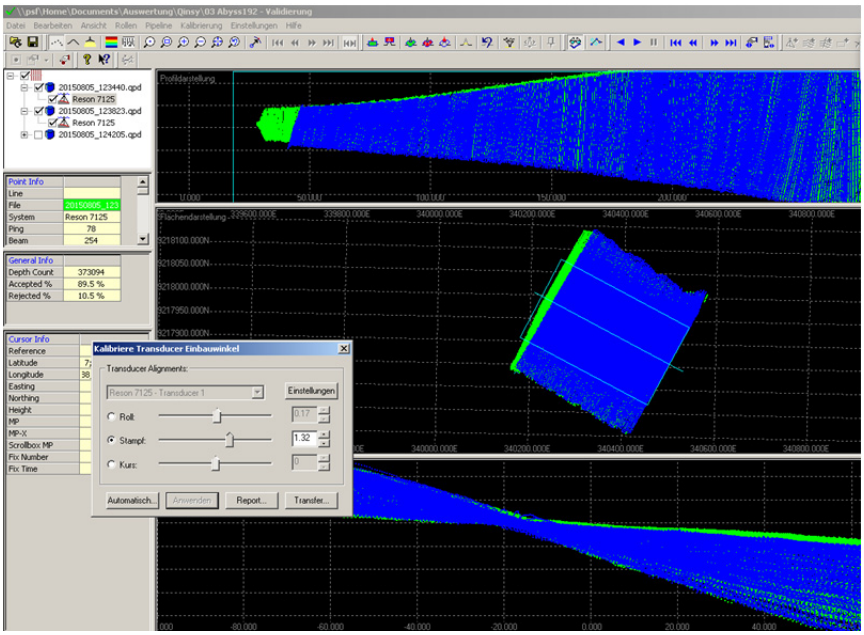


Figure 7.5.1.1: Data correction

After applying mounting offsets the navigation was adjusted using the MBnavadjust tool of the software package MB-System (Caress und Chayes). MBnavadjust interactively determine horizontal and vertical offsets in overlapping or crossing swaths to match bathymetric features. Iterative navigation adjustment is required for dealing with multiple surveys.

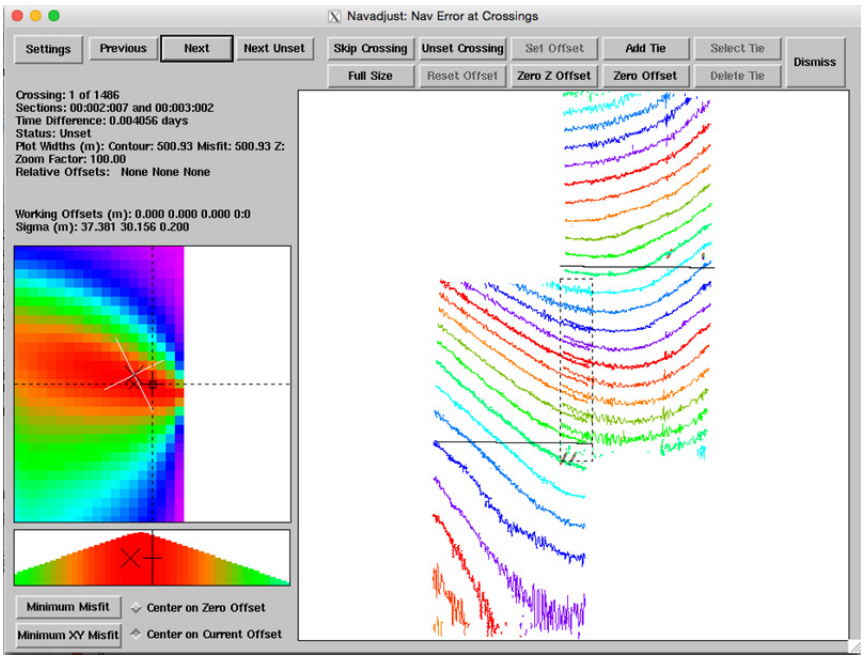


Figure 7.5.1.2: Screen shot of the MBnavadjust tool

Bathymetry editing , export, gridding and visualization were carried out using QINSy/Qloud (QPS).

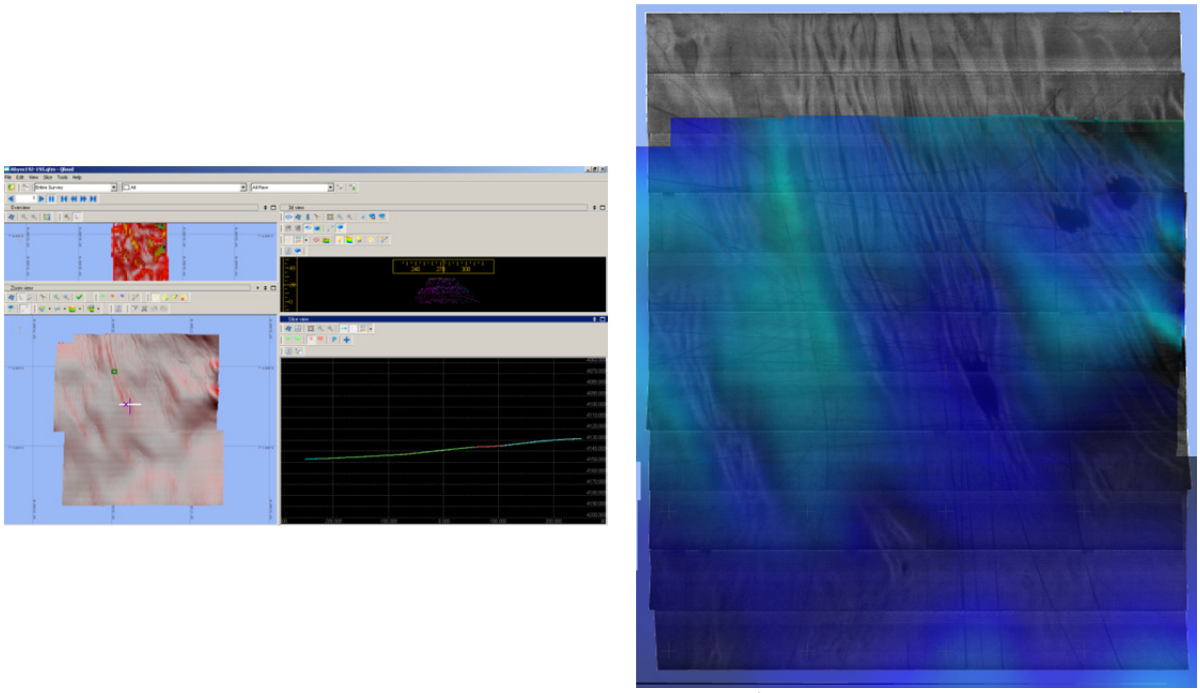


Figure 7.5.1.3: Screen shot of the QINSy/Qloud tools.

Sidescan post processing

The sidescan raw files were processed by using the software CleanSweep (Oceanic Imaging Consultants, Inc.). After loading data into the project, the tracks were automatically broken up into swath for excluding turn data from final mosaic. The „AutoSwath“ routine uses the heading data to break a track into swaths whenever the rate of turn exceeds a threshold. Manually adjusting the swath defined exactly what data to include.

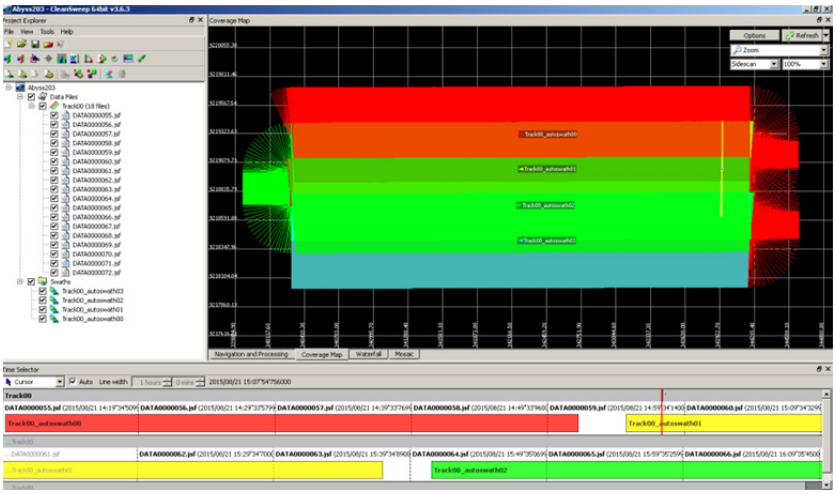


Figure 7.5.1.4: Screen shot of the CleanSweep tool for determining swath overlap.

The next step in processing the sidescan imagery was setting the bottom tracking. Automated bottom tracking removed most of the water column. Some areas needed manual edits. AUV navigation always includes some position errors during data acquisition. CleanSweep provides two options for making corrections, InterNAV Anchor Points and InterNAV Feature Points. By using objects visible on adjacent swaths and using known locations, InterNAV can be assigned to shift the navigation data into the correct location in a relative and an absolute sense. Features in overlapping swaths especially visible tracks for example of an EBS in the working area were used to align the swaths.

Figure 7.5.1.5: Preliminary mosaic that still needs amplitude adjustment across the swath.

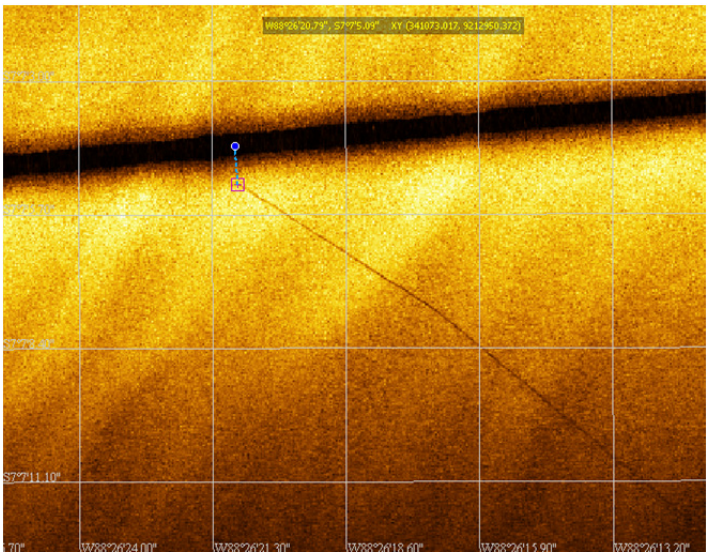


Figure 7.5.1.6: Sidescan map showing one of the EBS tracks used for swath alignment.

Image Enhancement followed navigation adjustment. Angle Varying Gains (AVG) have been compensated for backscatter variations due to system beam-pattern irregularities and natural variation of backscatter with angle of incidence. Look Up Tables (LUT) stretches the contrast of the raw data to fit the available display dynamic range. Finally step was remosaicking with a resolution set to 0.5m and Exporting as GeoTiff. CleanSweep offers several export options.

7.6 Box-corer

Clara F Rodrigues, Patricia Esquete, Nils Brenke, Hannes Post, Gerd Schriever, Henko de Stiger, Asmus Petersen

Macrofauna introduction and objectives

The German DISturbance and reCOLonization experiment is one of the first attempt to study deep-sea community responses to artificial disturbance of an extended sediment area. In the past box corer (BC) samples obtained during all post-impact expeditions from the disturber tracks (disturbed treatment) were compared with un-ploughed sediments from the experimental field (undisturbed treatment) and with samples from un-impacted reference sites of the surrounding area (reference treatment).The results showed that the experimental treatment caused severe abundance depletion in the disturbed areas, but the subsequent development surprisingly did not follow the previously hypothesized scenario, as recovery of the fauna began very rapidly (Borowski 2001). During this DISCOL REVISTED cruise SO242/1, the main goal of the box core sampling was the study of the macrofaunal assemblages. The biological material collected during the cruise will contribute to attain the following specific objectives:

- To gain more information on the biodiversity and distribution ecology of macro invertebrates in the area;
- To assess differences between different areas (e.g. references with nodules, disturbed area)
- To evaluate the progress of the macrofaunal communities after 19 years.

The equipment

A box-corer (USNEL Spade Corer; Hessler&Jumars, 1974) was used to sample the sediment inclusive macrofauna as well as associated nodules (Figure 7.6.1). The box is made of a 50 cm x 50 cm x 60 cm that sinks into the bottom. A friction release frees the spade arm when the weight of the

corer is relieved from the wire. When wire is reeled in to return the device to the ship, the initial action is to lever the spade down into the substrate until it closes off the bottom of the core. Subsequent take-up on the wire pulls the apparatus out of the bottom. At the top of the core box a cylindrical valve allow free passage to water entering at the mouth. The valve is opened during the descent and closed by a friction release mechanism triggered by the spade closure.

Figure 7.6.1: The box corer in its full beauty (Foto B. Barenbrock).

Operation of the gear

The box-corer was deployed from starboard side and lowered at a speed of 1 m/s until it reached an altitude of 100 m above the seafloor. After a stop of about one minute, the box-corer was lowered at a speed of 0.4 m/s down to 50 m above the seafloor and landed at a speed of 0.2 to 0.3 m/s. The winch was stopped 20 seconds after landing and the box-corer was pulled out after another 20 seconds to give the gear time to sink into the sediment. The whole operation was monitored on a plot of rope tension. Landing was visually assessed by a significant drop in rope tension. Pull out tension for a successful box-core ranged from 49 to 53kN according to substrate and depth. In total, the box-corer was deployed 26 times, 25 deployments were successful.

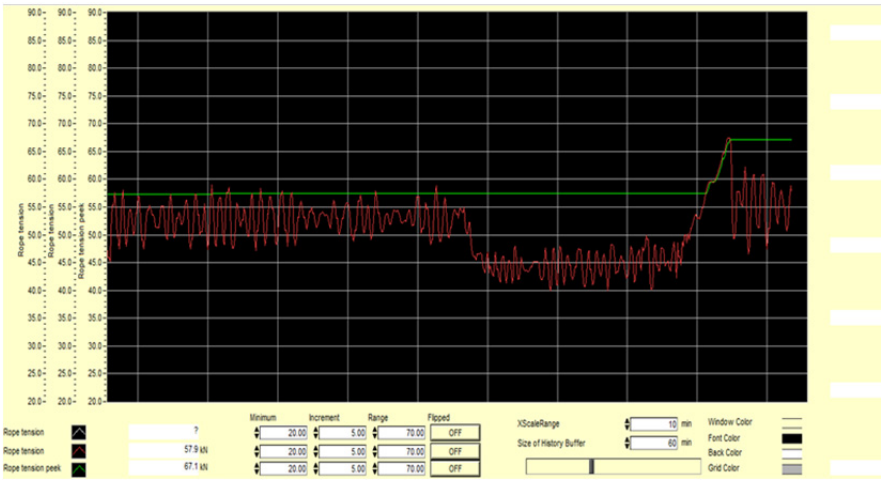


Figure 7.6.2: Variations in rope tension during landing and pull of a box corer (#87_BC-14).

Shear Strength Measurements

In each box corer sample two vertical shear strength profiles (10, 20, 30 and 40 cm from sediment surface) were measured using a handhold shear strength probe based on a vane and its mechanical turning resistance in the soil or sediment measured by a calibrated torsion spring. The shear strength probe has a measuring range from 0 to 200 kPa (Figure 7.6.3). These geotechnical shear-strength measurements provide background data for biological, geochemical, geological and environmental studies as well as for sea floor stability analysis on sea floor properties, necessary for the development of exploration and exploitation tools to be used at the sea floor.

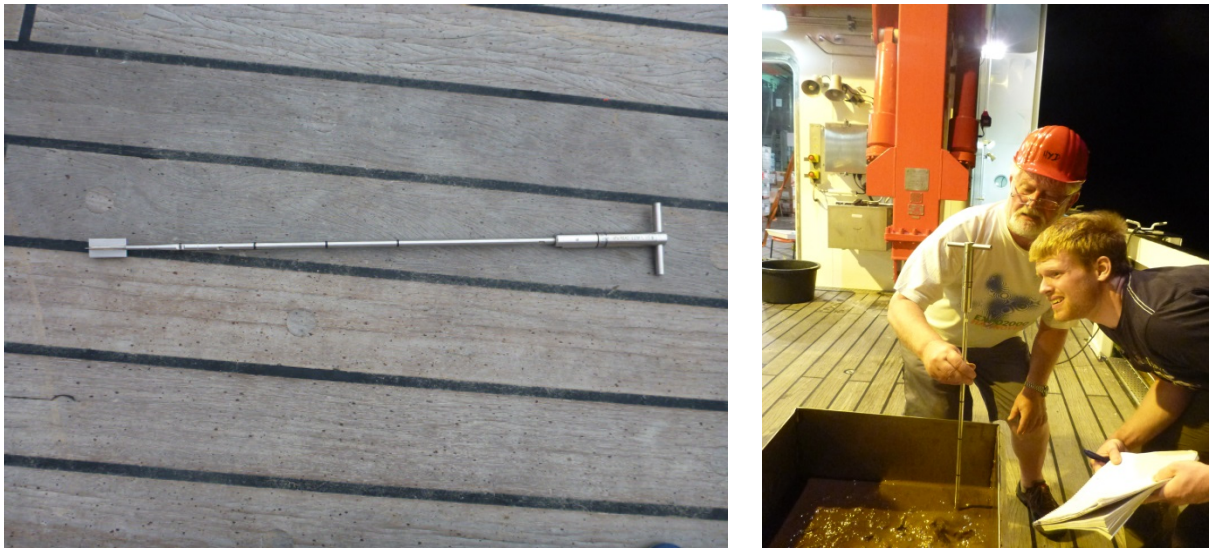


Figure 7.6.3: Left the shear-strength probe laying on deck; right the probe in operation within the box corer.

7.7. Multicorer

Ravail Singh, Great Egho, TasminYunus Patel, Guy De Smet, Pedro Martinez Arbizu

Research objectives

A large-scale experiment, DISCOL (Disturbance and recolonization experiment in a manganese nodule area of the deep South Pacific) was conducted to evaluate potential impacts from mining on the deep-sea community. The Multicorer was used to collect undisturbed sediment samples from the DEA. The corers were processed to study the geochemical settings, including oxygen penetration, bioturbation, trace elements etc. (see chapter 7.16), granulometry, TOC, POC, photosynthetic pigments and meiofauna community structure and diversity. Main objective was to measure these factors within old tracks and compare with historical undisturbed reference sites, in order to understand the resilience of benthic communities after anthropogenic impact and the time-scales of recovery. In addition to the current date comparison of disturbed and undisturbed sites, we aim at comparing current diversity with data from the DISCOL cruises for selected taxa. Four stidy sites were sampled, the heavily disturbed areas in the DEA, as well as the three reference areas in the south (with nodules), the west (with nodules) and the east (without nodules). The material collected during the cruise will contribute to reach the following specific objectives:

- To evaluate the progress in recovery of the meiofaunal assemblage inhabiting the disturbed site by comparing with available literature
- To assess the biodiversity and distribution ecology of meiofauna community in the impacted and un-impacted area
- To assess the differences in meiofauna community between different areas (e.g. references with nodules, previously disturbed, etc)

Description of the gear

For this study we used the same Oktopus multicorer that was used during SO239 in the CCZ (Figure 7.7.1). The gear is armed with 12 corers (inner diameter: 94 mm, area of 69.4 cm2). For taking the samples within old tracks, the gear was complemented with a TV-Camera system that send live video stream through the LW-cable, allowing for precise positioning of the multicorer within the tracks at the seafloor. Geographic position of the gear was achieved with a Posidonia transponder attached to the cable at 100 m from the gear. A MAPR was attached to the cable 1 m below the Posidonia transponder to measure parameters in the water column (see chapter 7.3). The multicorer was lowered with a speed of 1 m/s till about 50 m above the seafloor, where it was stopped for approximately 1 minute and then lowered with a speed of 0.5 m/s until contact with the seafloor was monitored through the cable tension or a video camera. For video guided landings the heave-compensation was switched on at 2 meters above the bottom. The corer was left on the seafloor for about 2 minute, then pulled out of the sediment with 0.5 m/s and latter lifted with 1 m/s. For statistical reasons, each station was sampled with five deployments, excepting the last one (reference without nodules) were deployments could not be achieved because of time constrains.
Attempts to operate the Multicorer from the back using the A-Frame, resulted in 5 unsuccessful deployments, because of releasing and closing of the tubes in the water column. Operating the Multicorer from the side resulted in much better success, although with some empty corers, indicating that some of the corer still closed in the water before reaching the bottom. The reason for this was found to be a miss functioning in the hydraulic damping of the gear. After fixing the problem, the gear usually retrieved 12 full corers. The corers were processed and distributed as shown in Table 7.7.1.

In most cases eleven to twelve tubes were filled with about 30 cm of sediment. However the first five deployments were not successful. Sediment cores were distributed among different groups; geochemistry (for pore water geochemical research; GEOMAR, JUB), molecular taxonomy of Ostracods and Forams (RBINS), meiofauna investigations (University of Ghent and morphology and molecular analyses of meiofauna (Senckenberg). Moreover, few of the deployments were specifically taken from sediment plume areas, black patches and in the reference area without nodules for geochemical purposes; nevertheless the corers were distributed among the different research group. An overview of the distribution of the multicorer samples between the working groups is given in Table7.7.1. More detailed information about the distribution of the material from each working area along with stations is detailed in each specific section of chapter 8.

Figure 7.7.1: The multicorer on deck of RV SONNE (foto B. Barenbrock)

Sampling/Subsampling processing

Once the multicorer was back on board, the water overlying the sediment sample was sieved through a 32-µm mesh sieve. The upper layer (0-5 cm) of the core was sliced to study the meiofauna. Samples were washed through a sieve column (32 µm) with filtered seawater. All sieve residues were preserved in 4% formol for morphological taxonomy and in DESS for molecular analyses. Pictures during the processing of the core were taken (Table 7.7.2). When present the nodules were observed and visible epifauna was removed, preserved in 96% ethanol and kept separately; Nodules were then removed and gently washed in cold sea water to remove most of the sediment sticking to the nodules.

Table 7.7.1: Distribution of MUC core liners for each study site

1st DEPLOYMENT (liner number)	**following DEPLOYMENTS**
(1-4) Geochemistry	(1) Abiotics Ghent University
(5) Abiotics Gent University	(2) -80°C Gent University
(6) -80°C Gent University	(3) Formol Gent University
(7) Formol Gent University	(4) DESS Gent University
(8) DESS Gent University	(5) Ostracods&Forams Ethanol (RBINS)
(9) DESS Senckenberg	(6-8) DESS Senckenberg
(10-12) Formol Senckenberg	(9-12) Formol Senckenberg

Figure 7.7.2: MUC sampling in the lab, day and night.

Table 7.7.2: Stations detail in each working area and the distribution of cores from each of the MUC operation (Geochemistry=GEOMAR & JUB; RBINS=Royal Belgian Institute of Natural Science; NIOZ=Netherlands Institute for Sea Research)

Station #	MUC #	Sample distribution	Area	Warer depth
242/1_#19	MUC 1	empty	Ref south	4161
242/1_#22	MUC 2	empty	Ref south	4139
242/1_#24	MUC 3	empty	Ref south	4162
242/1_#28	MUC 4	empty	Ref south	4159
242/1_#29	MUC 5	empty	Ref south	4159
242/1_#34	MUC 6	Total cores recovered=8 Geochemisty=4 Gent Uni=2 Senckenberg= 2	Ref south	4161
242/1_#35	MUC 7	Total cores recovered= 12 Gent uni=4	Ref south	4159

		RBINS=1 Senckenberg=7		
242/1_#39	MUC 8	Total cores recovered= 8 Gent uni=4 Senckenberg=4	Ref south	4162
242/1_#40	MUC 9	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	Ref south	4163
242/1_#44	MUC 10	Total cores recovered= 10 Gent uni=4 RBINS=1 Senckenberg=5 Two cores were empty	Ref south	4159
242/1_#46	MUC 11	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	Ref south	4162
242/1_#56	MUC 12	Total cores recovered= 12 Geochemistry=5 Gent uni=3 Senckenberg=4	DEA (heavily disturbed)	
242/1_#61	MUC 13	Total cores recovered= 12 Geochemistry=4Gent uni=4 Senckenberg=4	DEA (heavily disturbed)	
242/1_#62	MUC 14	Total cores recovered= 11 Gent uni=4 RBINS=1 Senckenberg=6	DEA (heavily disturbed)	4154
242/1_#64	MUC 15	Total cores recovered= 8 Gent uni=4 Senckenberg=4	DEA (heavily disturbed)	4153
242/1_#65	MUC 16	Total cores recovered= 10 Gent uni=4 RBINS=2 Senckenberg=4	DEA (heavily disturbed)	4151
242/1_#70	MUC 17	Total cores recovered= 7 Geochemistry=5Gent RBINS=1 Senckenberg=1	DEA (heavily disturbed) Sediment plume	4127
242/1_#71	MUC 18	empty	DEA (heavily disturbed)	4127
242/1_#73	MUC 19	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	DEA (heavily disturbed)	4121
242/1_#74	MUC 20	Total cores recovered= 12 Geochemistry=4 (1 return to RBINS) Gent Uni = 4 Senckenberg=4	Black Patch	
242/1_#79	MUC 21	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	Ref west with nodules	4133
242/1_#80	MUC 22	Total cores recovered= 12 Geochemistry=4 Gent uni=4 Senckenberg=4	Ref west with nodules	4129
242/1_#90	MUC 23	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	Ref west with nodules	4125
242/1_#91	MUC 24	Total cores recovered= 12	Ref west with nodules	4127

		Gent uni=4 RBINS=1 Senckenberg=7		
242/1_#108	MUC 26	Total cores recovered= 12 Geochemistry=4 Gent uni=4 Senckenberg=4	DEA (disturbed east)	4169
242/1_#109	MUC 27	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	DEA (disturbed east)	4161
242/1_#110	MUC 28	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=6 Henko=1	DEA (disturbed east)	4174
242/1_#114	MUC 29	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	DEA (disturbed east)	4159
242/1_#115	MUC 30	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	DEA (disturbed east)	4157
242/1_#119	MUC 31	Total cores recovered= 12 Geochemistry=4(1core returned to Senckenberg) Gent uni=4 NIOZ=1 Senckenberg=3	Ref east without nodules	4204
242/1_#130	MUC 32	empty	Ref east without nodules	4204
242/1_#131	MUC 33	Total cores recovered= 12 Gent uni=4 RBINS=1 Senckenberg=7	Ref east without nodules	4203

7.8 Gravity Corer

M. Haeckel, A. Petersen

To carry out geological and geochemical sampling of the deeper sediments a gravity corer (GC) was mobilized (Fig. 7.8.1). The GC was equipped with a weight of 2000 kg and a 10-m long core barrel and was operated by the large movebar of the ship. In general the GC was lowered into the sediment with a rope speed of 0.8 m/s to recover maximum core lengths, but avoiding over-penetration. After the retrieved GC was back on deck the inner plastic liner (inner diameter of 110 mm) was pulled out and cut into 1-m long segments that were then cut lengthwise into a work and an archive half using a homeworker table saw. The archive half was used for the geological core description and sediment photography (chapter 9.4 & 9.5), while the work half was transferred to the ship's cold room for sediment sampling and subsequent geochemical analyses. After finishing this work, the sampling and the archive halves were transferred into D-tubes for long-term storage at GEOMAR's cooled core repository. For precise locations of the coring gear at the seafloor, the ship's POSIDONIA underwater navigation system IXSEA was attached to the wire approximately 50 m above the GC (chapter 7.14). During the cruise 7 gravity cores were taken at the different investigation sites in the wider DISCOL area (Table 7.16.2) recovering a total of 93.37 m of sediment (recovery rate: 93 %).

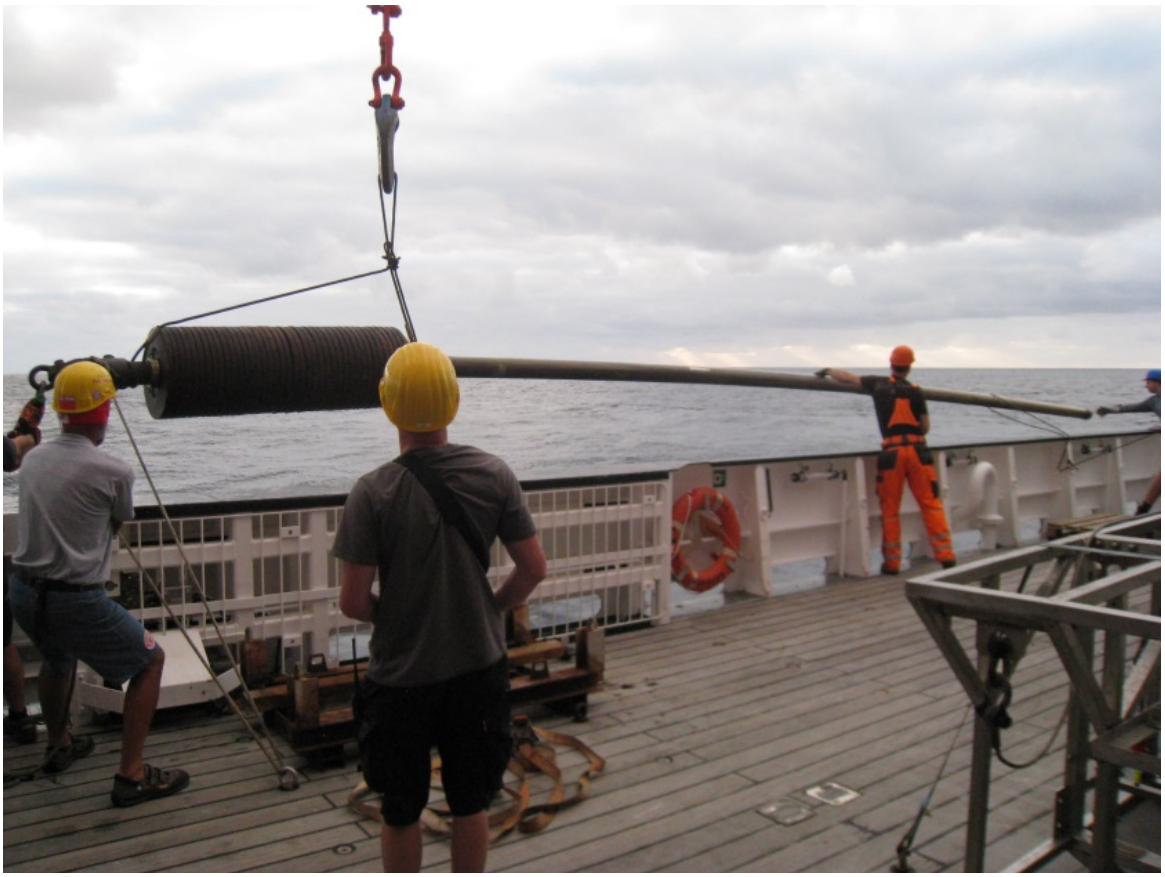


Figure 7.7.1: Gravity corer (GC) with 10-m barrel and 2-t head weight.

7.9 Camera Epibenthic sled

N. Brenke

Description of the Gear

The mechanic construction of the "CliSAP-Sled" (C-EBS: constructed in the framework of the "Integrated Climate Analysis and Prediction Excellence cluster" in Hamburg in 2010) is based on the sled frame of Brenke (2005). The C-EBS is 3.6 m long, 1.2 m high and 2.4 m wide (Figure 7.9.1). The whole frame is constructed of stainless steel, nominal diving depth is 6000 meters (600 bar), weight 880 kg (in air).

Epibenthic sleds are widely used in the deep sea for the sampling of benthic epifauna as well as benthic macrofauna. For biological sampling the gear is equipped with two plankton nets (500µm): the lower epinet and the upper supranet. The outlet of the net buckets in the cod ends is covered with nets of 300 µm mesh size. To avoid catching planktonic organisms within the water column, an opening-closing mechanism closes two flaps in front of the nets. If the gear touches the ground the weight of the sled open the flaps and animals will be captured. In order to keep the samples cool on their way through the water column in tropicl warm waters for genetic analyses, an isolation box around the cod ends was installed. Especially for the work in areas with Mn-nodules, at first a net (8x8 cm) and second metallic grids (2x5 cm mesh size) were attached to the entrance of the sampler to avoid collection of nodules, which may clog or damage the nets (Fig. 7.1.7.1). Thus, the samples are not quantitative.

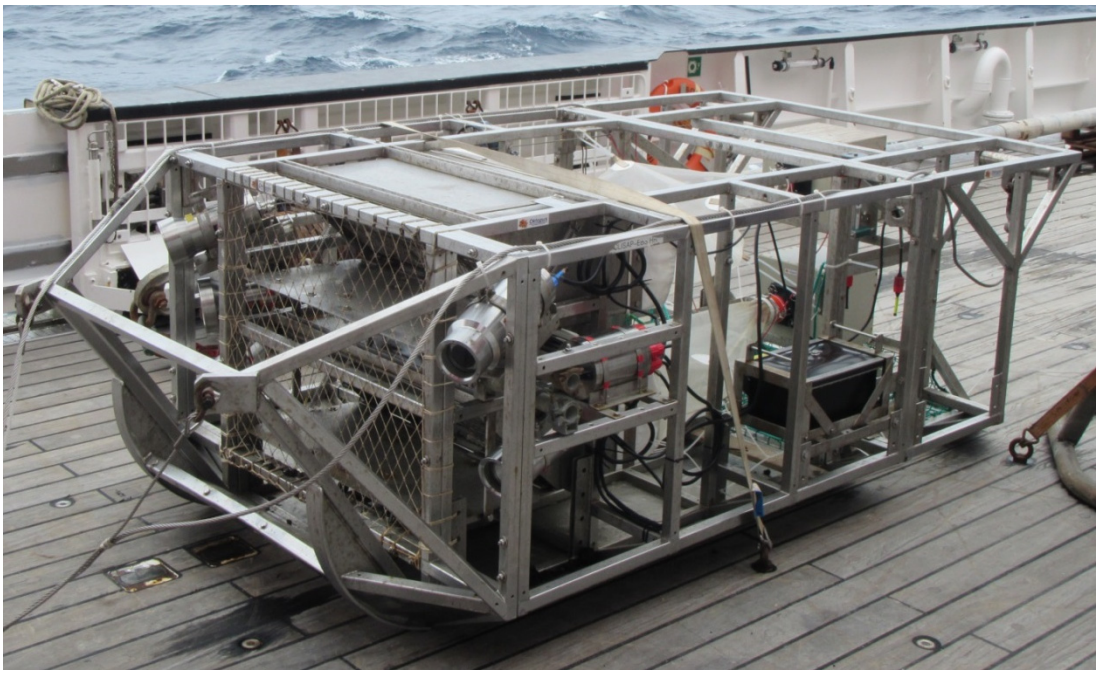


Figure 7.9.1: CliSAP- epibenthic sled.

The C-EBS is characterized by a heavy sidly enlarged frame. These lateral extensions carry the underwater photo- and video cameras for the visual observation of the seafloor as well as auxiliary equipment. The entire system is powered using an oil-embedded deep-sea battery which provides 24V, two times 14 Ah. This allows an operating time of app. 3 hours (Brandt et al. 2013). From a Seaguard (RCM DW-6000 DCS) system sensor data about current speed and direction, temperature, salinity, O2 concentration and saturation as well as pressure are available. An USBL transponder shows the geo-referenced position of the gear on ground (Fig. 7.9.2).

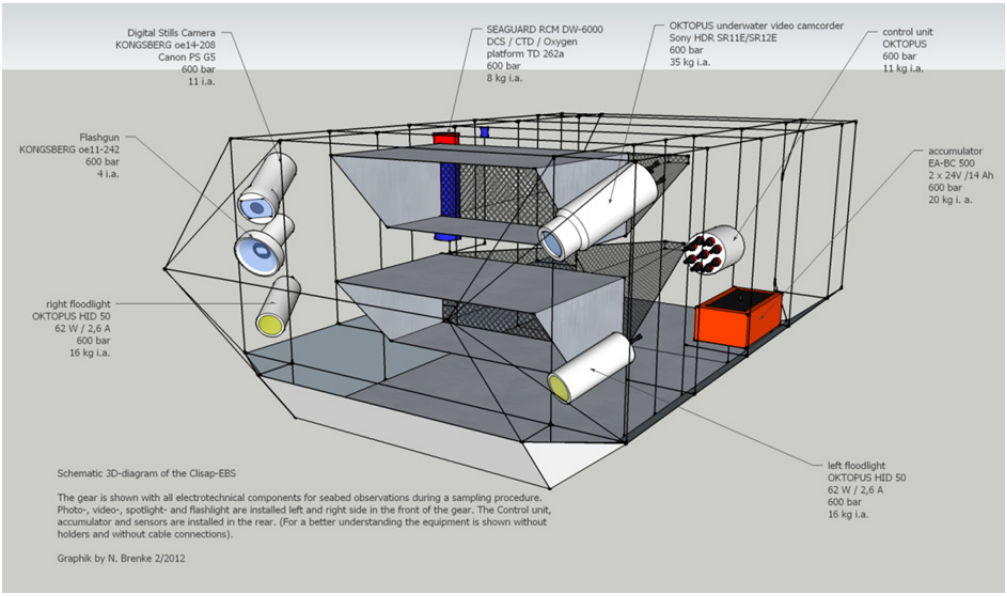


Figure 7.9.2 Schematic sketch of the CliSAP- epibenthic sled.

Operation of the gear and handling of samples on board

For the C-EBS deployment the ship starts at a position 2.4 km (1.3 nm) prior to the assumed ground contact position. The ratio cable length to water depth is 1.6 times. The wire was paid out

with 0.7 m/s while the vessel speed was 1 kn. About 50 m above the ground the C-EBS was lowered with 0.5 m/s until the tension meter indicated that the C-EBS was on the ground. The rest of the wire was paid out (~4400 to 6600 m) with 0.7 m/s while the vessel speed was 1.2 kn to lay out the wire tightly and straight in front of the EBS. After the maximum wire length was achieved the ship kept on going with 1.2 kn to stretch the wire tight. After 10 respectively 20 min the vessel kept the position and the winch started to heave the C-EBS with 0.5 m/s. When the gear left the ground, the winch speed was increased to 1 m/s.

7.10 Amphipod / Ostracod Baited Traps

Henri Robert and Tasnim Patel

The purpose of our investigation was to assess the impacts of potential deep-sea mining of manganese nodules on the biodiversity and community structure of deep-sea Amphipoda and Ostracoda. Subsequent to the participation of Henri Robert in cruise JPIO SO239 in March 2015, our plan now is to compare specimens of amphipods and ostracods collected from the Clarion-Clipperton Fracture Zone (CCZ) to the DISCOL" (DISturbance and re-COLonization) experimental area (DEA). We aim to assess the genetic patterns of divergence spatially across the CCZ and DISCOL area. In addition, we aim to investigate the connectivity between the different spatial populations, checking specifically for the presence of cryptic species and dispersal capabilities of the different taxa. This will be pioneer research in a previously unexplored area.

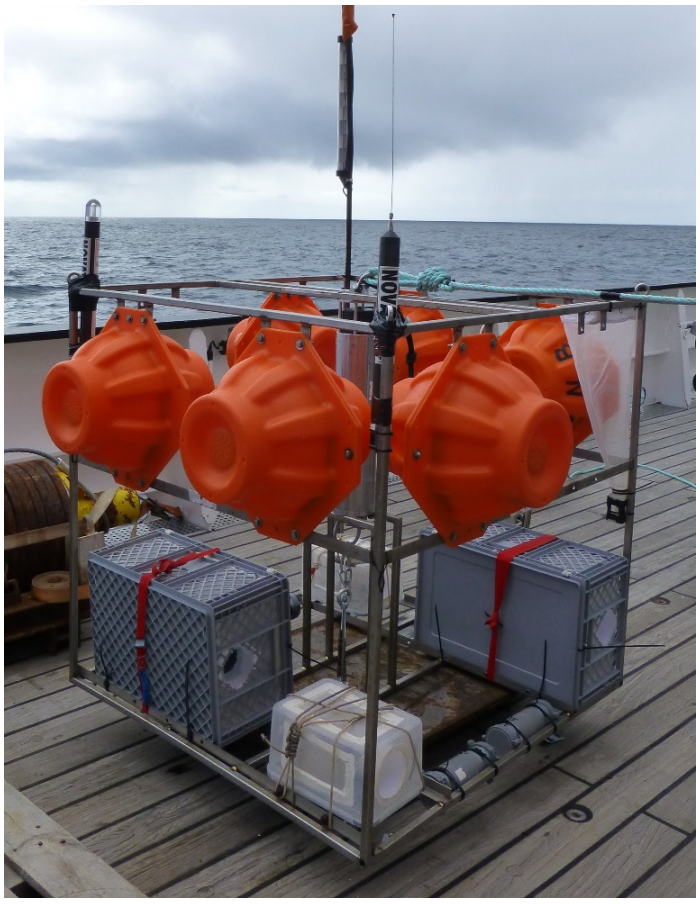


Figure 7.10.1: Image showing the different sizes of baited traps used. There were 2 large grey boxes and 2 smaller white boxes for the Amphipoda. In addition, there were 6 cylindrical ostracod traps attached. 4 of these were at the base and 2 were 50 cm above the base. In the upper right corner of the cage, the configuration of our plankton net is shown. Foto T. Patel

Description of the Gear

During this cruise, amphipods and ostracods were collected using baited traps on a free-fall lander (Figure 7.10.1) and the Epibenthic Sledge (EBS) which has captured several specimens of amphipods (so far unsorted) at each dive. Two different types of baited traps were used. Small ones (20x25x40 cm) and large ones (25x40x60 cm) made of plastic boxes equiped with a fine mesh on each side to allow bait smell diffusion, attraction and trapping as well as having 2 funnels per trap directed inwards. These had an opening of 2 and 4 cm for the small traps and 4 and 8 cm for the large ones. The size of the entrance was calculated to capture small scavengers (i.e. amphipods) in the small traps and larger ones (i.e. larger amphipods, fish or decapods) in the larger traps.

The bait we used consisted of about 800 gr of unprocessed defrosted mackerel per trap. To prepare the trap, first the mackerel is wrapped into two layers of cotton net of 1 cm mesh size. This is to encourage fast access to the bait and to keep specimens tangled until the recovery of the traps. All traps are attached to the bottom of a cubic metallic lander (Figure 7.10.1) (120x120x120 cm) equiped with six 15" flotation spheres, a Novatech radio beacon, a Novatech flash unit, a flag and an Ixsea Oceano acoustic release transponder (RT861-CS). The transponder is Posidonia compatible for positioning at the sea-floor, and monitoring of the ascension through the water column during recovery. The weights which we used as ballast each consist of 3 plates of metal (75x75 cm) attached together at the center with a 30 cm screw and bolts which are connected to a small chain with a metal ring for easy disconnection of the ballast and the releaser during the recovery operation.

Ostracoda were captured with specially designed "Ostracod traps" (inspired from the traps described in Nakajima *et al*., 2013 and Nishida *et al.*, 1999). These traps consist of PVC cylindrical tubes (Figure 7.10.2) of approximatively 1 liter (base of 8 cm in diameter) obstrued at each extremities by 125 µm mesh in which 14 holes (diameter of 2 mm) were made. During each deployment, 4 ostracod traps were attached on the amphipod lander as close as possible to the bottom of the frame and to the sea-floor sediment. This was to increase contact between the traps and the sediment and to allow benthic ostracods to crawl up on the mesh and enter the trap. During the 3 final deployments, 2 additional traps were added 50 cm above the standard traps. These were designed to trap any benthic swimming ostracods. Ostracoda from the water column were also collected at each lander deployment site using a small plankton net (entrance: 15x30 cm) attached to the upper corner of the lander (Figure 7.10.1).

Figure 7.10.2: Image showing the cylindrical ostracod traps. Foto T. Patel

7.11 Ocean Floor Observation System (OFOS)

José Nuno Gomes-Pereira, Erik Simon Lledo, Jens Greinert, Kevin Köser, Evangelos Alevizos

OFOS dives planned during SO242/1 aimed to map megafauna species distributions, community structure and biomass along undisturbed areas and areas with disturbance, ranging from the highly disturbed centre of the DEA to the undisturbed reference sites allocated outside the plough experiment. Together with previously taken image datasets, these dives will allow for temporal analysis of fauna recolonization and for a time-independent community spatial assessment. OFOS dives were also useful for the groundtruthing of acoustic data (i.e. sidescan based plough mark map). Furthermore, OFOS footage will enable a correlation with other imagery datasets collected during the expedition along exact same transects with different gear (i.e. 8m taken AUV pictures). This could provide an interesting insight for future the development of megafauna monitoring protocols after mining/disturbance events.

Sampling/Survey

A standardized approach was adopted to allow addressing the different scientific objectives, including comparison with previous datasets, allow other questions to be addressed as well as future comparisons with the data collected. Stratum selection: Four different stratum were considered following the classification by Bluhm et al. (1995), corrected in Bluhm et al. (2001), comprising Disturbed Areas (inside Plough DEA), Undisturbed areas (outside plough mark in DEA), Reference areas with Mn-Nodules, and reference areas with NO Mn-Nodules. To try and capture variation between these areas we designed a stratified random survey, according to these four stratums or areas of interest:

- '**Disturbed areas'**: areas within the DEA directly disturbed by the plough-harrow. The sediment surface was disrupted by the disturber and covered by a thin layer of resettled sediment. Only a few manganese nodules remained on the sediment surface. Most were ploughed under.
- '**Undisturbed areas'**: areas within the DEA not directly influenced by the plough-harrow, but which showed various levels of re-sedimentation of sediment plumes created by the disturber.
- '**Reference areas'**: areas outside the DEA not affected by the disturber; with nodules, and without nodules.

The survey design took in consideration the minimum survey area estimates provided by Bluhm (2001) for Megafauna and OFOS first dive SO242-1_#43_OFOS1, particularly seafloor area coverage by the video and photographic camera, and the average speed. Based on these, and the available cruise time to deploy the OFOS system, dives were planned to cover a length of 3.6 km, in three 1200m transects per dive. A total of 6 OFOS dives were undertaken, 4 for megafauna analysis and 2 for geologic terrain classification where megafaunal records were also collected. The starting point of the biologically aimed dives was obtained by random selection of a point within a 300x300 square box, allocated within each of the areas of interest. The 2 geologically aimed dives were directed towards prominent topographical units detected in the fine scale bathymetry collected during AUV dives. A description of each dive can be found in section 8.1.5.

OFOS data annotation and data processing

Data was annotated in real-time using OFOP (Ocean Floor Observation Protocol). Video was recored in the recording software ArcSoft Total Media Extream, to MP4 using codec h264. Annotation fields for the annotation interface were customized according to local fauna and following the CCFZ (ISA, 2014) and DISCOL (Bluhm, 2001) online megafauna atlas, improved with new morphotypes compiled by Erik Simon from recent CCZ cruises (JC120, May 2015). A list of megafaunal descriptors used in the classifications of taxa and morphotypes during SO242-1 is provided as appendix of this section.

Description of OFOS gear used

Two OFOS systems were used, i.e. two different metal frames with downward looking video and/or photographic cameras and lighting systems, towed close to the seafloor to collect images of the benthic environment with known area coverage. In the first OFOS dive (OFOS1), a lander launcher structure was used (see figure below). In the following OFOS dives, the MUC system was used as the frame for deployment. The system was increasingly capacitated for seafloor surveys from OFOS2 to OFOS6, with lights, stereo cameras and a CTD throughout the dives as described and illustrated below.

Figure 7.11.1: OFOS setup on a TV-guided MUC frame used in most OFOS dives in SO242/1 (top) OFOS control room with video displays, two computers used for real-time annotation and a screen displaying video intranet of the different winch (bottom).

In all dives two colour video cameras Oktopus GmbH and one light Oktopus HID 50 were used. Figure 7.11.2 summarizes the workflow. The signal was received by the telemetry wet unit and transmited to the lab via fibber cable. The deck unit was an Oktopus GmbH VDT 3. The signal was than displayed on a Sony Television and retransmitted to another LCD screen for a larger display, with the possibility of receiving an overlay and signal amplification with the Kule DTT. One of the video signals was recorded using an external video converter Hauppouge! HD PVR, converting the signal to .mp4 with h264 codec, and recorded in a PC computer using the ArcSoft - Total Media Extream. One camera was placed downward/vertical and the other in oblique view in relation to the seafloor and only one of these cameras was recorded on each dive. The vertical camera providing a flat view was the most often recorded except on OFOS4 and OFOS6. A compass cable was used to maintain a constant distance to the seafloor. The cable length and correspondent distance to the seafloor and field of view was variable between dives to allow testing of different camera setups and in other cases avoid contact in areas of roughed seafloor. The average field of view for each OFOS video was calculated and is provided in Table 8.1.5.1.

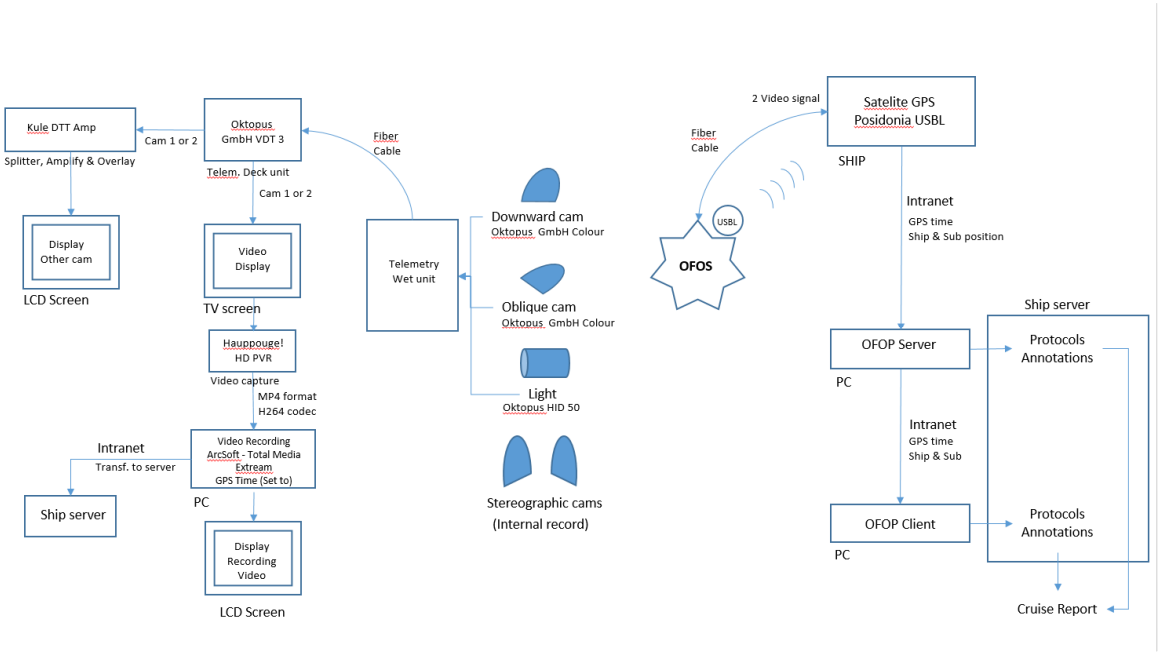


Figure 7.11.2: Ocean Floor Observation system workflow during cruise SO242/1.

The OFOS dives were also used to test a novel stereo camera system that is currently being developed at GEOMAR (Figure 7.11.3). The system consists of two Teledyne Dalsa Genie TS cameras (12 megapixel, bayer-pattern color) behind domeports with 10cm diameter. The cameras were equipped with a Zeiss Distagon 18mm lens, that provides a horizontal field of view both in air and water of approximately 70°. On deck, the bottom of the cameras was approximately 41cm above the ground and they were mounted 30cm apart with slightly converging optical axes such that the footprints on the ground have maximum overlap at 2.5m distance (1mm per pixel resolution). The cameras were powered through the telemetry (lamp2 power connector) but the video was recorded locally and was not transmitted to the ship, as the telemetry does not provide ethernet network access. The cameras were synchronously triggered at 1Hz, which allows to see each seafloor point more than 10 times at an OFOS speed of 0.5 knots over ground. Different exposure times, apertures and digital amplification strategies have been tested.

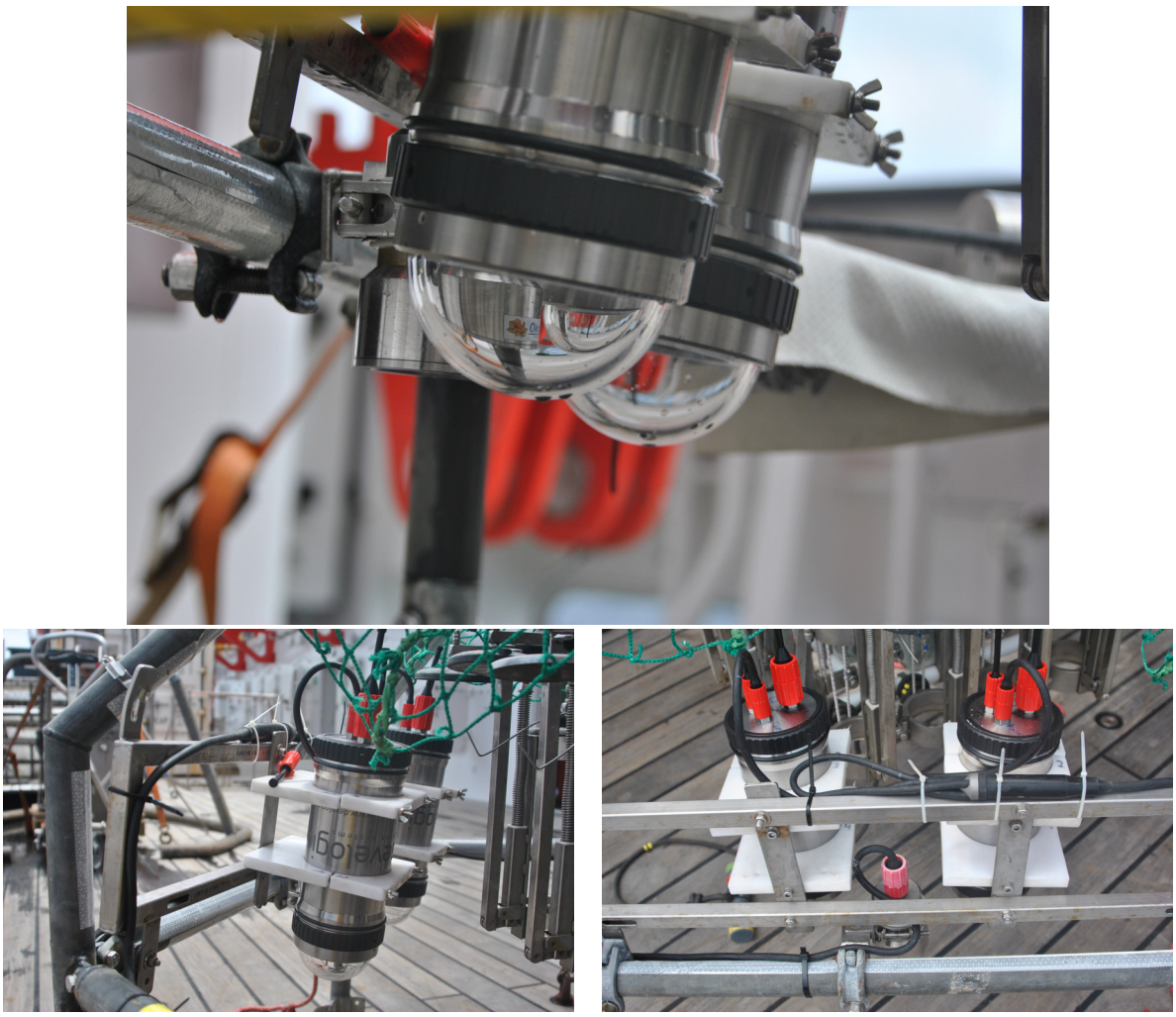


Figure 7.11.3: The stereo photographic camera system with the PAL video camera from Oktopus in the centre attached to the OFOS frame and facing downward used in OFOS surveys.

Oktopus camera calibration

In order to obtain an accurate estimate of the field of view of the recorded PAL cameras, one of them was calibrated by capturing a video on deck while presenting a chessboard calibration target (see http://geomar.de/go/cameracalibratrion-e for further information). It can be assumed that the field of view of the other Oktopus video camera is similar, which could not be recorded during the calibration procedure. The camera suffers from significant radial distortion that make straight lines on deck appear curved. At the middle of the left image boundary the distortion moves pixels by 5% of the image width (see sample image). In the following the field of view is given for undistorted images, the real image has a less than 10% larger field of view in both directions. The undistorted field of view in air is 59° horizontal and 46° vertical. Because of the refraction at the air/glass/water boundary at the flat port, the overall system is no longer a camera with a single center of projection. However, when considering the outer most rays, they form a field of view in water of 47° horizontal and 35° vertical (about 51° by 38° considering also distortion). The detailed coefficients as given by the tool biascalibratecamera (http://www.mip.informatik.uni-kiel.de/tiki-index.php?page=BIAS) run on 218 video frames are given below.

<?xml version="1.0" encoding="UTF-8"?>
<Projection Version="0.1">
<ProjectionParametersPerspective Version="0.1" Focallength="668.9974976" Skew="0">
<ProjectionParametersBase Version="0.2">
<Identifier val=""/>
<VideoSourceType val=""/>
<ImageSize width="768" height="576"/>
<PrincipalPoint x="367.1343689" y="268.0662842"/>
<AspectRatio val="1.024105145"/>
<Rotation>0.175574136378 0.109344294216 -0.840705572563 0.500431502025 </Rotation>
<Center x="6.386299608" y="7.084785172" z="-31.09878303"/> </ProjectionParametersBase>
<Distortion k1="-0.4058530629" k2="0.1384259313" p1="0" p2="0" Type="DISTYPE_DEF"/>
</ProjectionParametersPerspective>
</Projection>

Because of missing video feedback during calibration, the chessboard (Figure 7.11.4) was not optimally positioned, so the outer image parts might suffer from a few pixels miscalibration, which is however not significant for footprint calculations in square meters.

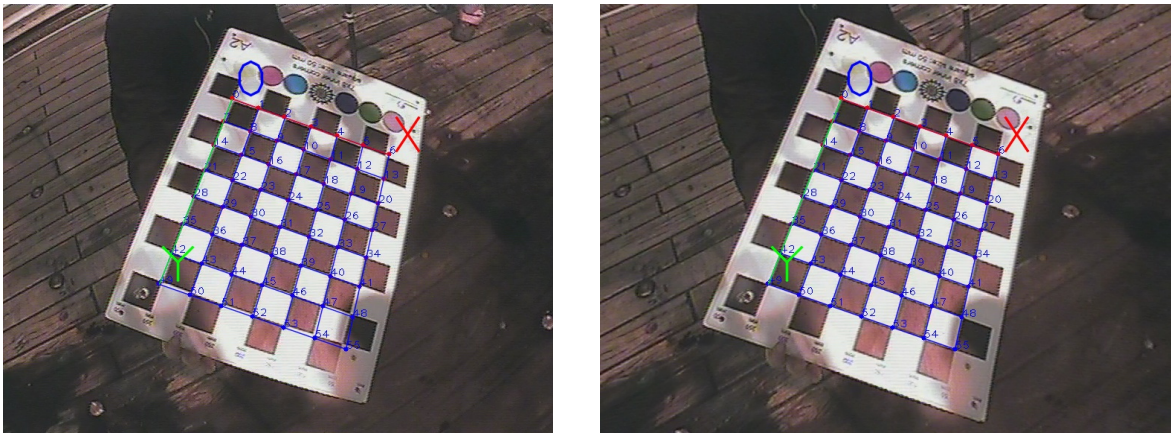


Figure 7.11.4: Chessboard with overlaid straight line pattern shows significant radial distortion. Right: Undistorted image during camera calibration.

Detailed description of each OFOS setup

SO242/1_#43_OFOS-1

The OFOS camera system used for dive SO242/1_#43_OFOS-1 used 1 light and 2 video cameras Oktopus (Figure 7.11.5). The compass reference cable was 1.6 m (Cable)+ 0.2 m (Weight), totalling a 1.8 meters height. The distance from the weight to the seafloor was kept regular between 1 – 1.5 m from the seafloor. The Field of View was 6.5 - 7.4 m, calculated by lifting the OFOS on deck at known heights, and using a reference scale on the deck (Figure 7.11.6). The weight on the end of the cable was 10cm wide as seen from above. This method allowed to confirm the previous field of view estimate using the chessboard based calibration.

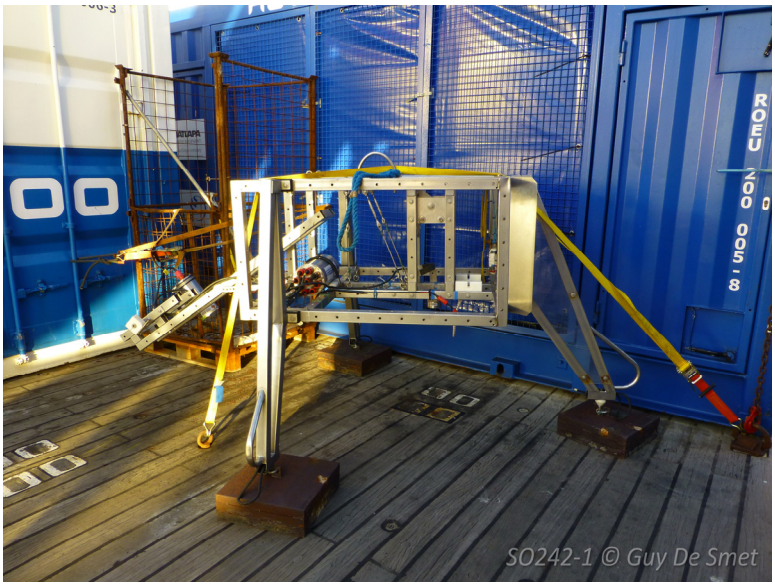


Figure 7.11.5: Lander launcher used during dive SO242/1_#43_OFOS-1.

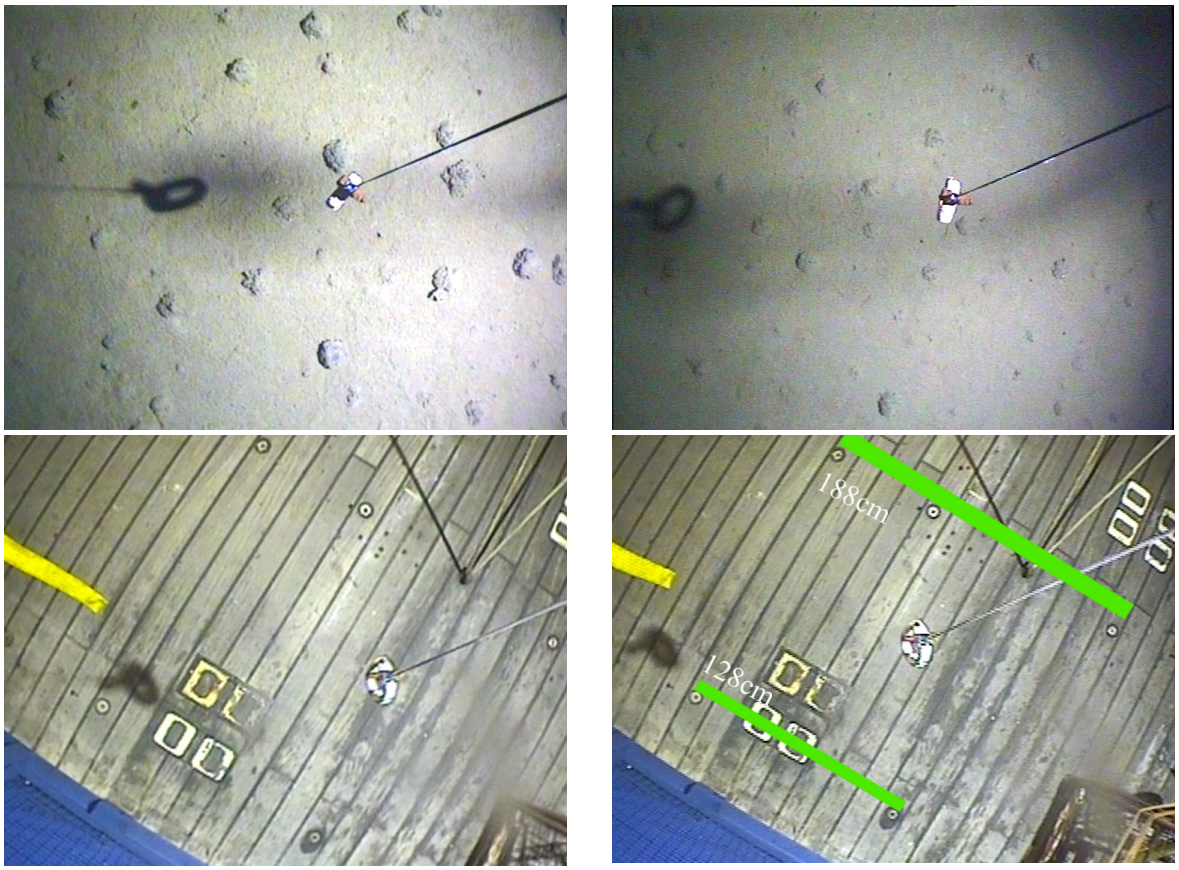


Figure 7.11.6: Field of view estimation from OFOS1 and comparison with in situ images

SO242/1_#76_OFOS-2

The OFOS camera system used for dive SO242/1_#43_OFOS-2 used 1 light and 2 video cameras Oktopus (Figure 7.11.7). Additionally, two stereo cameras were placed one on each side of the video camera (see description above). Only one of the cameras recorded imagery. The setup had little light for the stereo camera image. On this dive the video recorded was from the downward looking camera. The compass reference cable and weight measured a total of 2.5 m below camera lenses focal point. The video recorded was black and white.

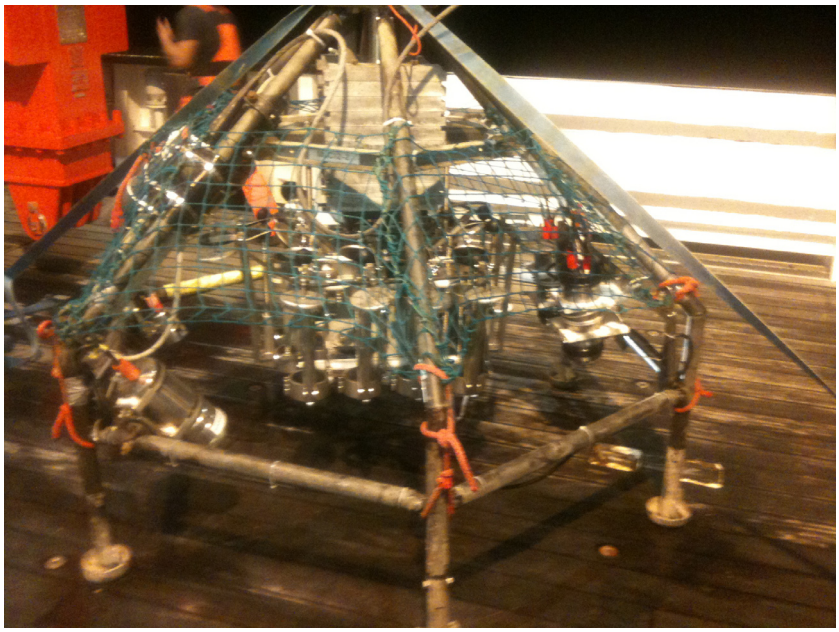


Figure 7.11.7: OFOS setup used in OFOS-2

Figure 7.11.8: Picture of the tool attached to the end of the 2.5 m rope to be used for seafloor size reference

SO242/1_#76_OFOS-3

The OFOS camera system used for dive SO242/1_#43_OFOS-3 used 1 light and 2 video cameras Oktopus (Figure 7.11.9). Additionally, two stereo cameras were placed one on each side of the video camera (see description above). The compass reference cable and weight distanced a total of 1,5 m from camera lenses focal point. The setup had still little light for the stereo camera images. On this dive the video recorded was from the downward looking camera.

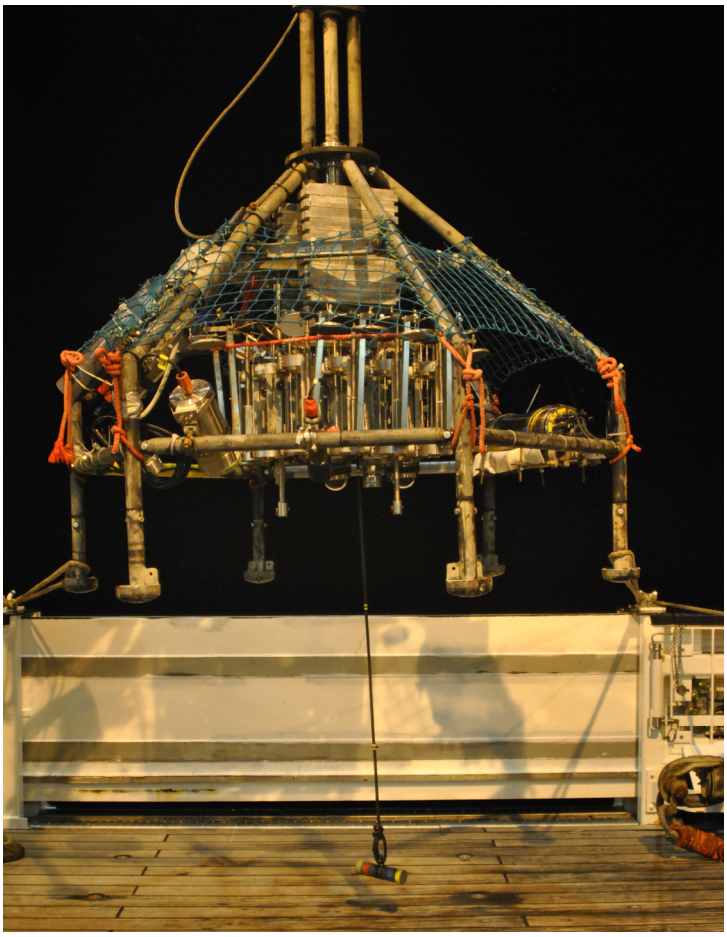


Figure 7.11.9: OFOS setup used in OFOS-3

SO242/1_#76_OFOS-4

The setup was the same as the previous dives. Only the compass reference cable and weight was increased, distancing a total of 2.5 m from camera lenses focal point to avoid contact with a roughed seafloor. The setup had still little light for the stereo camera images. On dive OFOS4 the video recorded was from the oblique looking camera.

Figure 7.11.10: MAPR attached to OFOS (left) and oblique Oktopus camera and lamp (right).

SO242/1_#134_OFOS-5

The setup was similar to the previous dives. Only the compass reference cable and weight was changed to 1.5 m from camera lenses focal point. The cable was attached at 50.5cm horizontal distance from the camera focal point. An extra LED light of SeaArc^{tm} 3xeS and battery system was added (Figure 7.11.11) and placed obliquely towards the seafloor, on the opposite side of the stereo

and cameras in the structure, next to the light used in all OFOS surveys. A video overlay with date, time a cruise project was used in the video recorded for time synchronization.

Figure 7.11.11: Extra LED light of SeaArc^{tm} 3xeS added for the OFOS5 St134 dive

SO242/1_#135_OFOS-6

The setup was the same as the previous dive (OFOS-5). Only the compass reference cable and weight was increased, distancing a total of 2 m from camera lenses focal point to avoid contact with a roughed seafloor. The LED light was not used and the video recorded was from the oblique looking camera (Figure 7.11.12). A video overlay with date, time a cruise project was used in the video recorded for time synchronization.

Figure 7.11.12: Oblique camera used in the video recording.

Temporal variation of megafauna assemblages

For this objective, previous data collected during cruises SO061, SO064, SO077 and SO106 were addressed critically during cruise SO424/1 towards designing a strategy for re-analyse this data, allowing comparison with the data being collected during the cruise SO242/1 and SO242/2. A total of 42 OFOS dives were previously performed in the DEA using video and a photographic camera. The photographic material was digitized and geo-referenced prior to cruise, being available for annotation in DIAS via intranet in the ship. This critical analysis included re-calculating the field of view of the previous OFOS systems, classify previous photographic material as opportunistic or systematic (of paramount importance for area surveys), and start the annotation/classification of selected previous photographic data.

Specifications from OFOS systems with relevance for megafaunal assessments, concern mostly the field of view (FOV). The FOV was calculated for previous cruises as they were not mentioned in the cruises reports, as shown in the Table 7.11.1. The calculations and are briefly discussed below. Still some FOV of view from previous cruises only be obtained. For full specifications on OFOS systems from cruise SO242/1 see the sections below on “description of gear”.

Table 7.11.1. Summary of general specifications of previous and current OFOS surveys in the DISCOL.

Cruise	Year	View Angle	Compass (m)	Av. Alt	Camera Model	FOV (m^2)
SO061	1989	oblique NA	Cable (+weight?)	NA	Benthos 372A	NA
SO064	1989	oblique NA	Cable (+weight?) 3	3	Benthos 372A	6.9
SO077	1992	vertical	Cable (+weight?) 3.4	3.4	PHOTOSEA 5000	NA
SO0106	1997	vertical	Cable (+weight?) 3.4	3.4	PHOTOSEA 5000	NA
SO242/1	3 Aug 2015	vertical	Cable + weight 1.8	3	Oktopus GmbH	5.9
SO242/1	12 Aug 2015	vertical	Cable + weight 2.5	3	Oktopus GmbH	5.9
SO242/1	18 Aug 2015	vertical	Cable + weight 1.5	2	Oktopus GmbH	2.6
SO242/1	18 Aug 2015	oblique	Cable + weight 2.5	3	Oktopus GmbH	5.9
SO242/1	22 Aug 2015	vertical	Cable + weight 1.5	2	Oktopus GmbH	2.6
SO242/1	23 Aug 2015	oblique	Cable + weight 2.5	2.5	Oktopus GmbH	4.1

The Ocean Floor Observation System (OFOS) system used in cruises SO061 and SO064 is described in detail in the Cruise Report of SO061 (by Karl Stenkamp). The EXPLOS/OFOS system used in cruises SO077 and SO106 is described in detail in the Cruise Report from SO077 and SO106. However, in both cases, no detailed account was given on the Field of view (FOV) estimates. This information is crucial to develop unbiased quantitative estimates of objects and marine life on the seafloor. Below we detail how field of view estimates were obtained for past and current OFOS systems used in the DISCOL area.

Regarding OFOS from cruise SO061 and S064, there is no information on camera angle, only reference to the camera model (Benthos 372A). Few images exist from the equipment. Images found in a TV during a documentary filmed onboard allowed to estimate the camera angle, at ca. 20,2 degrees (Fig. 7.11.13).

Another approach to obtain a coarse approximation for the tilt of the camera was developed based on the image taken by this OFOS, considering the camera view angles and cable length. First ignoring the distance of the weight: If we assume that the weight hangs directly from the camera and the camera looks down exactly in gravity direction, we would see it in the middle of the image. When I look at the picture from cruise SO061_OFOS007 IMG_3360.JPG, ID: 439207) it seems that the weight hits the ground just at the bottom of the image. The vertical field of view of the camera is 35º

degrees in water. If the rope would hang directly next to the camera (distance=0) then the tilt angle had to be 17º degrees (half image height). Now if the rope hangs further away from the camera, this add to the angle. If the rope is 3 m long, then - if it starts 1 m from the camera, add 18.4 degrees (=atan(1m/3m)) to that angle - if it starts 2m from the camera, add 33.7 degrees (=atan(2m/3m)) to that angle.

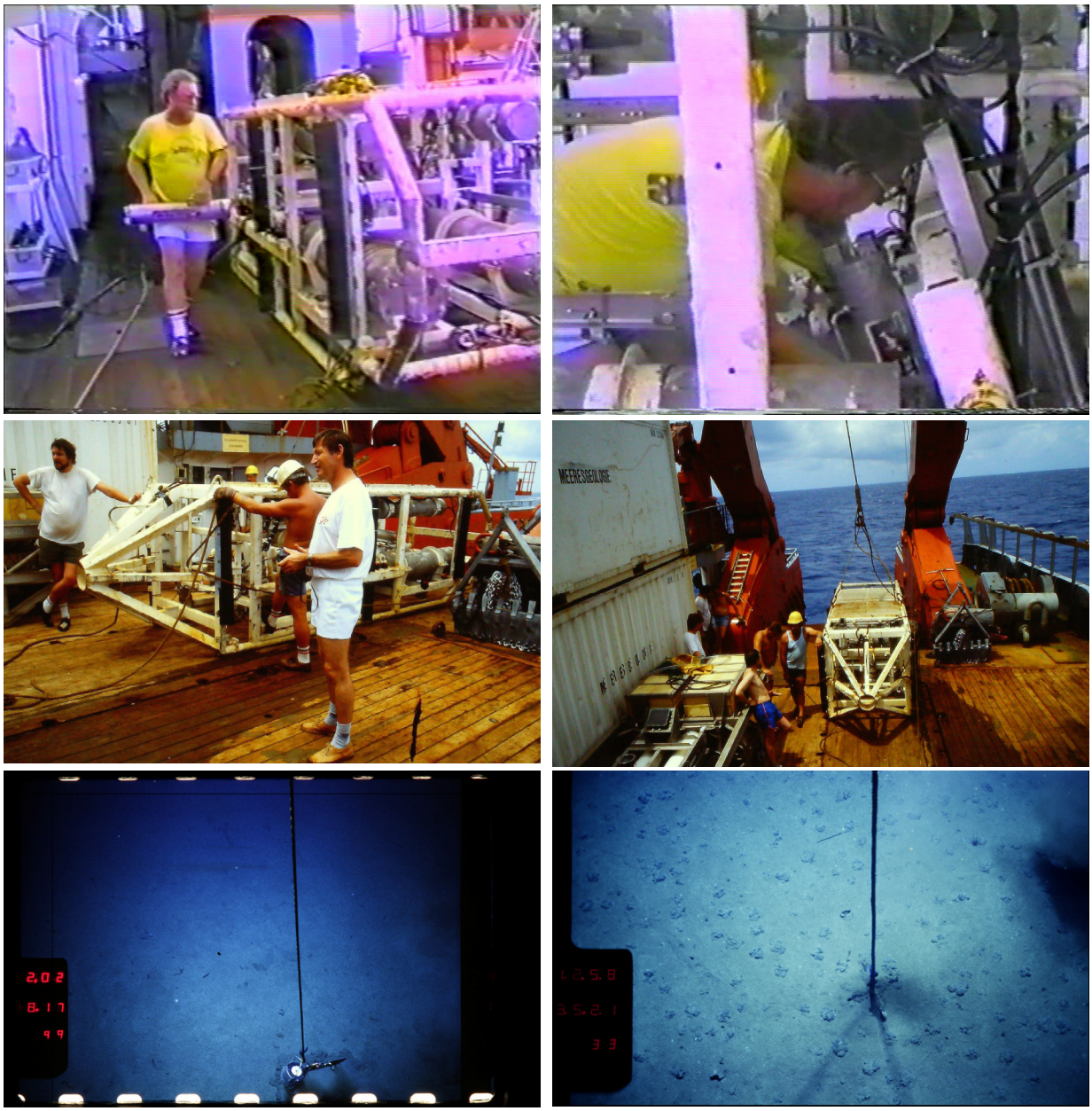


Fig. 7.11.13: (top left) Technician carrying the Benthos 372A camera next to the OFOS used in 1989 SO061 and SO064. (Top right) Technician placing the oblique downward camera in the OFOS used in SO061 and SO064; the image allows calculating the camera angle; (Mid Images) OFOS before deployment, photographed by Gerd Schriever; (Below Left) image collected from cruise SO061_OFOS007 IMG_3360.JPG, ID: 439207); (Below Right) image collected from cruise SO064_OFOS024; on both occasions the compass cable is in vertical position and touching the seafloor

According to this calculations, and assuming the weight was hanging from the front lower bar from fig. 1, and that this tight at ca. 20cm from the camera, it adds 3,8 degrees to 17 degrees = 20,8 degrees, which is pretty close to the 20,2º estimated from the image of the system. From a height of

3 m, and an angle of incidence min of 20,5 degrees and max of 55,5 degrees (35+20,5), vertical length over the seafloor was estimated at 3,24m; a base of 2,99, front of 4,49 and a total area of 12,85 m^2.

By comparing the OFOS images from cruises SO061 and SO064 it is clear that the compass cable was made shorter in the cruise SO064. In the cruise report of SO064 a reference is made regarding cable distance 3 m, and also to the systematic collection of images. It therefore greatly hinders obtaining a field of view estimate for images for cruise SO061. In cruises SO77 and SO106 a different OFOS system was used, the EXPLOS/OFOS (Fig. 7.11.14). The photographic cameras were used vertically facing downward, which based on camera horizontal and vertical angles of view underwater, and the height given by the compass cable and weight (3,4 m), an area footprint will estimated by consulting the PHOTOSEA 5000 camera specifications.

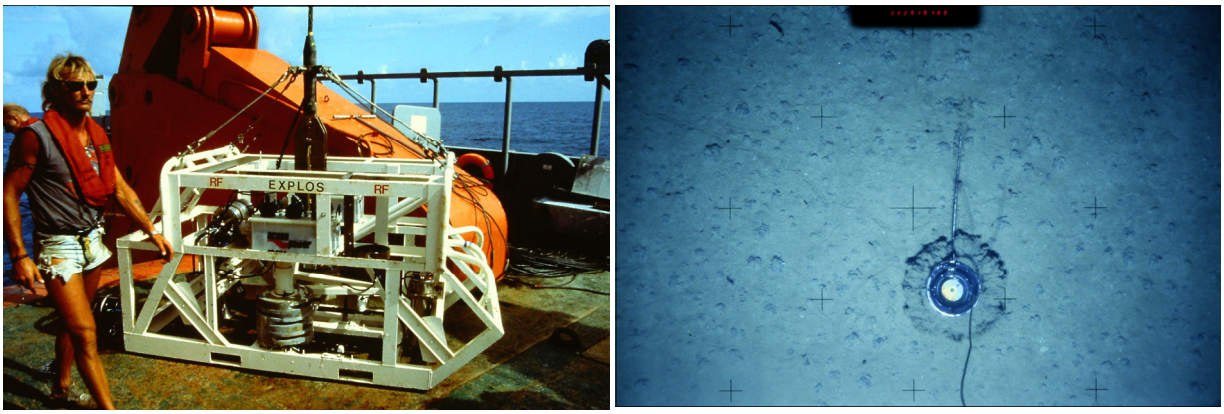


Fig. 7.11.14: EXPLOS/OFOS used in cruises SO077 and SO106 (1992 and 1996).

7.12 DIAS Image Annotation

José Nuno Gomez Pereira, Erik Simon Lloda, Timm Schoening

During SO242-1, visual image data was acquired by OFOS, Landers and TV-MUC but mostly by the AUV “Abyss”. For the rapid assessment of image content, manual image annotation was implemented using a prototype of the JPIO Image Annotation software DIAS. DIAS is a web-based software for the manual annotation of benthic images and the special use case of ship-based annotation (“Discol Image Annotation Software”). It is a successor of the software BIIGLE that is being used for the same purpose on shore. Annotation thereby refers to marking pixels within images as well as adding semantics to a whole image. DIAS is designed for image annotation only (no videos, frame grabs will work) and does not allow for live annotation (i.e. the annotation of live video feeds from the deep). The images have to be stored on the DIAS server for annotation. To be able to annotate during the cruise, DIAS was installed on a webserver onboard and made accessible over the ship’s intranet. The hardware structure of the setup is shown in Figure 7.12.1.

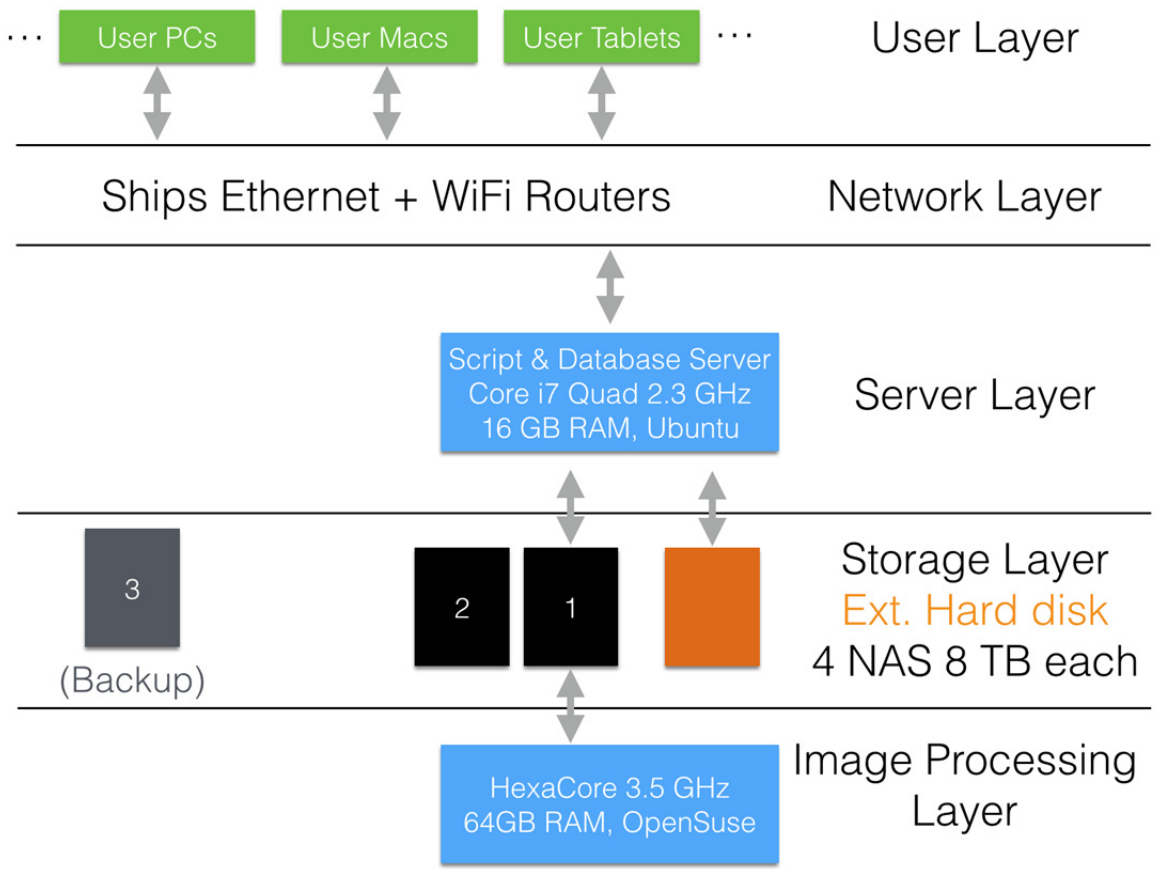


Figure 7.12.1: Users connect to the DIAS system using their own computers and the ships Ethernet.

Additional WiFi routers were added in some spots for connection convenience. The central part of the system is a server that distributes the data. This server is a powerful Script and Database server that also distributes the images. Here, the DIAS software is installed in the form of a PostgreSQL database and an Apache/PHP webserver. Users login on this server through the DIAS URL (dias.fs-sonne.de) and with their credentials. This server manages all the image browsing, data visualization and annotation methods.

The storage currently used is a single external hard drive connected to the DIAS server. This disk contains only a small fraction of the recorded data to allow for faster access time. The backup storage currently consists of one NAS server (16 TB, partitioned as RAID 1 with 8 TB) that contains all image data (Raw, FishEye distorted, calibrated). Another NAS is kept with copies of the same data for safety and later distribution among scientists. One further NAS is available in case the data amounts become too large for one NAS alone. The final, somewhat external, part is the Image Processing machine (DSM Computer “Palm”) that is used for removing the FishEye distortion from the images and to compute mosaics (see AUV Image Processing section).

The DIAS server was set up together with the two NASs in the Hydro-acoustic lab and all were connected to the ship’s Ethernet. DIAS was accessed during SO242-1 by the URL http://dias.fs-sonne.de. During the first days of the cruise, scientists gathered to learn how to operate DIAS by annotating images from SO239 and images acquired during old DISCOL cruises. Annotation categories focused on biological items with some abiotic categories for seafloor characteristics. Images from the AUV dives were added to DIAS (see Section 8.1.4). During the cruise, nine experts annotated 4622 items in 1392 images and used 113 different categories.

7.13 Photo mosaicking and photogrammetry

Kevin Köser

Similar to the maps produced from multibeam echo sounder or sidescan sonar, also visual maps and 3D models of the seafloor are useful for understanding the impact of the disturbance experiment, the current status of the DEA and also help to monitor, plan and validate experiments during the cruise (positions and type of seafloor where cores were taken or should be taken, etc.).

Visual maps are represented as mosaics in case the seafloor is flat, or can be surface textures of a 3D model for more complicated terrain. Very much like for acoustic data, also for visual mapping many shots are combined into a single big map, given the sensor position and orientation at capture time. To enable capturing visual data the AUV Abyss has been equipped with a custom-made photo system (GEOMAR) consisting of a high-resolution Canon 6D DSLR camera with a 15mm fisheye lens behind a dome-port (10cm diameter) and a flash system consisting of 24 high power LEDs. The dome port of the AUV conserves the geometrical properties of the lens, i.e. the field of view is not reduced in water. The system captured images at 3.5m-8m altitude at a rate of 1Hz and the AUV moves at a speed of 3kn (roughly 1.5m/s).

The central illuminated area of the image is cropped and fisheye-undistorted (camera calibration has been performed at GEOMAR before cruise SO-239). In the following we describe the numbers for 7m altitude, where a majority of the images has been captured, the footprint increases with higher altitudes and the resolution improves with lower altitudes. The resulting undistorted image from 7m corresponds to a photo taken from a rectilinear 18mm lens on 35mm film (90 degrees horizontally) covering roughly 150 square meters of seafloor. The overlap between subsequent images is more than 80%, i.e. we see each seafloor point 6 times along track, although the boundary regions of the image suffer from a low signal to noise ratio.

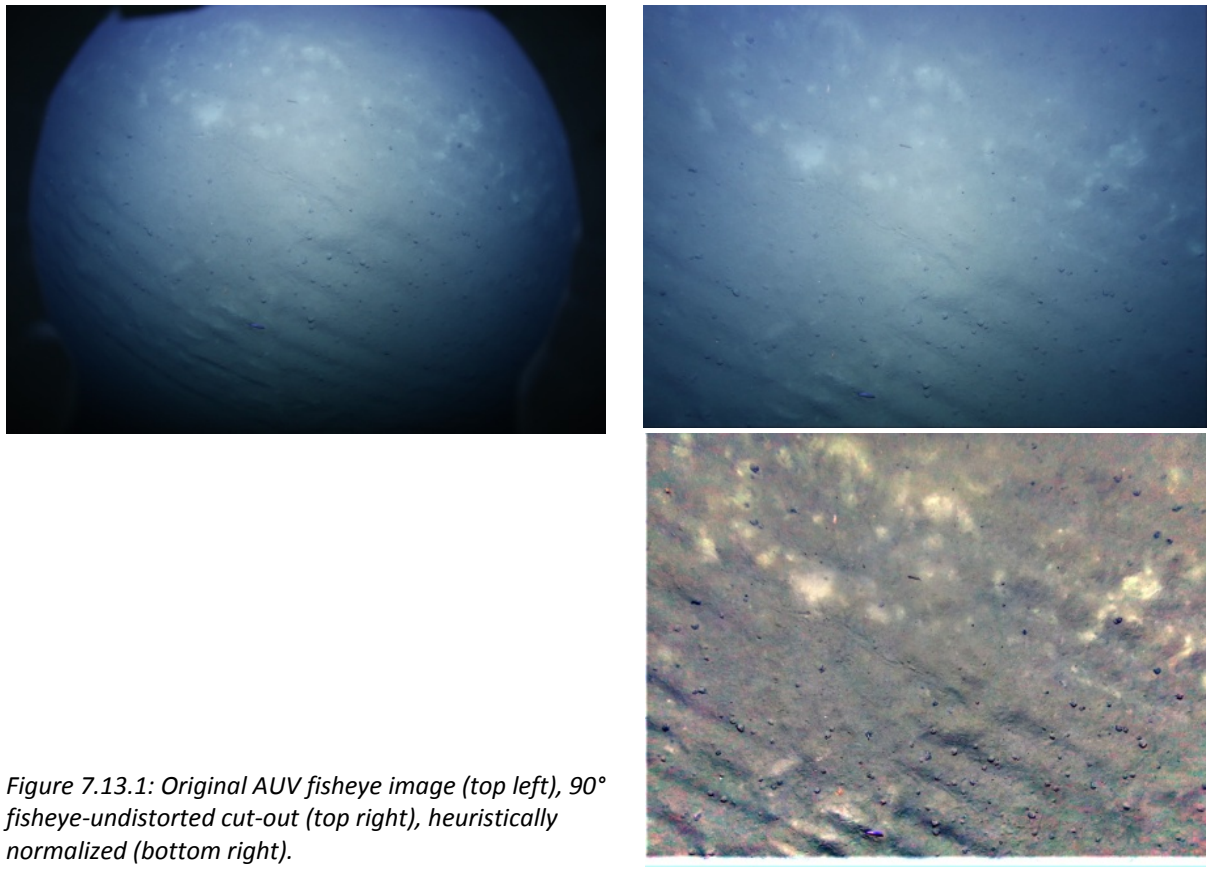


Figure 7.13.1: Original AUV fisheye image (top left), 90° fisheye-undistorted cut-out (top right), heuristically normalized (bottom right).

Because of the high altitude there is a lot of veiling light that degrades image quality. Also the lighting cone makes regions in the outer image part appear different from the central regions. In order to cover not only transects, but wider areas, the AUV flew various matresses of different lengths and line spacing. The line spacing was chosen to allow for approximately 50% overlap between adjacent lines. Two different approaches for photogrammetry and mosaicking must be distinguished.

1.) Photogrammetrically correct solutions find corresponding features in the images and compute the most likely camera trajectory given the images and the AUV's navigation data (bundle adjustment). When the images are aligned with (sub-)pixel accuracy, this allows also to extract 3D profiles and surfaces of tracks and to “undo” the color effects of light propagation through the water in the images. However, this is a computationally very expensive operation, given that we record 3600 photos with more than 20 megapixels each per hour (in the order of 40000 per AUV dive). This data will be processed back on land.

2.) Fast solutions that deliver useful approximate results already during the cruise. In order to generate reasonably smooth mosaics, the input images are heuristically normalized before further processing (the illumination differences are empirically inverted) and reduced to a resolution of 1cm/pixel. We then use the AUV navigation data to project all images onto the seafloor plane. Overlapping pixels are weighted according to the camera's distance to the seafloor point and mixed using a multi-band blending strategy to produce a grey-scale mosaic (Figure 7.13.2). The resulting maps (png files) have a 1cm resolution and are geo-referenced using UTM coordinates in zone 16 south (pngw world files).

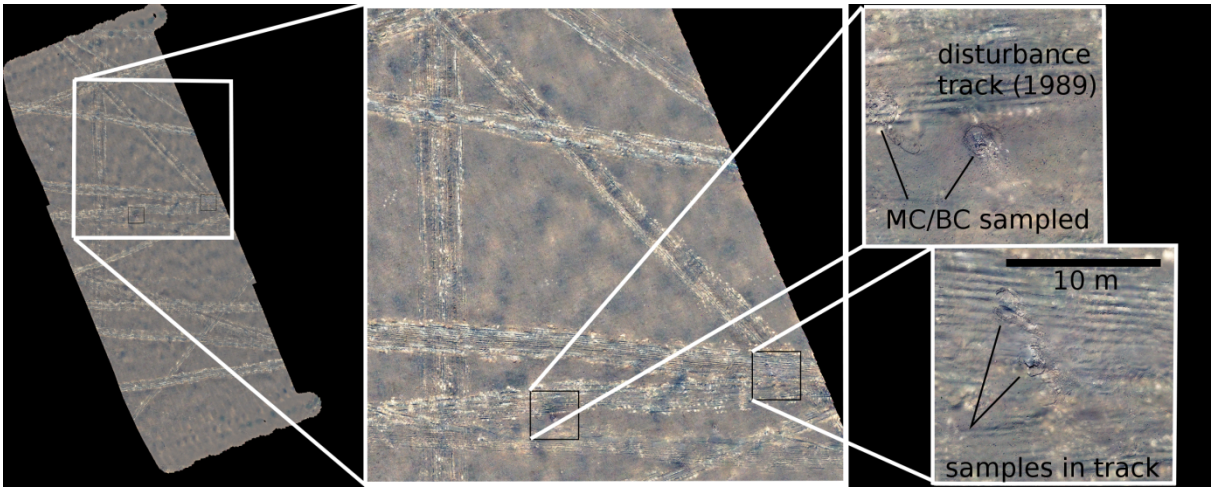


Figure 7.13.2: Generated photo mosaic of AUV mission Abyss_199 in the DEA using AUV navigation data only (no automatic adjustment using visual data).

Images and world files can be imported e.g. in ArcGIS and overlaid onto the station, sidescan or bathymetry maps and show individual manganese nodules and the relative locations of the impacts of gravity corer, multi-corer or box-corer as well as the lander(s). The map above shows a fraction of the DEA with tracks clearly visible.

7.14 Under water navigation and OFOP

Jens Greinert

Sampling and observations of the deep sea during research that depends on accurate positioning needs to be conducted with some kind of underwater navigational system. On RV SONNE the ultra short base line (USBL) system Posidonia from IXBLUE has been used. The system determines the distance and bearing of a transponder attached to the sampling gear based on the signal phase shift of the received signal by four hydrophones. Ships motion and ray tracing are considered and the absolute position of device at the seafloor is determined relative to the ships GPS position. On RV SONNE the position data are broad castes via the internal network and can be used with any kind of software for real-time plotting or data logging.

During SO242/1 we used the Ocean Floor Observation Protocol software (OFOP) installed on various computers on RV SONNE for real -time observations of the position of the sampling gear or the OFOS. OFOP was also used for real time video annotation (see chapter 7.11) and post processing of the acquired navigational data. For this logged navigational data of the USBL were edited, smoothed and subsequently splined to a 1 sec. data set. After that additional data as annotations were merged to this final navigational data set. Deployment positions were also defined based on this finally processed data set. Figure 7.15.1 gives an impression about the differences when editing navigational data.

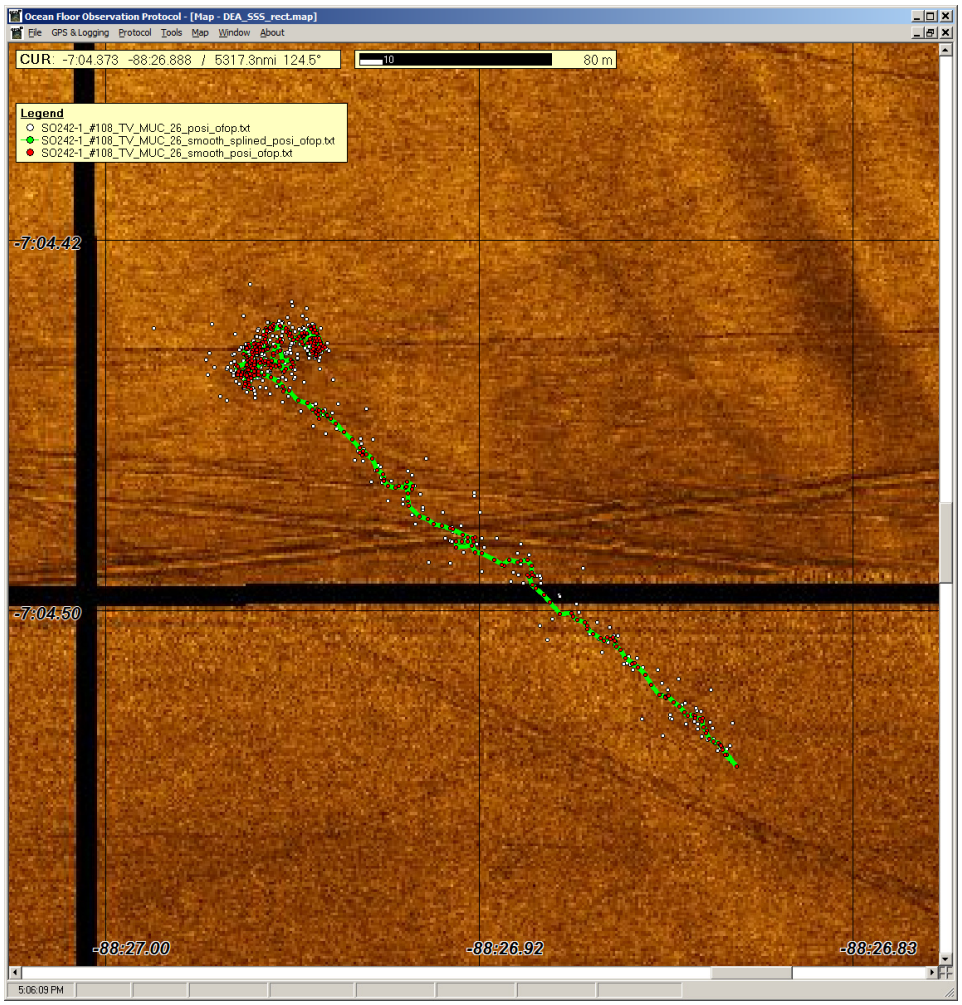


Figure 7.14.1: Screenshot of the main OFOP window showing the AUV sidescan map and data of station #108_TV-MUC-26. White dots are the original USBL data, red dots are the smoothed data after deleting outliers, the green line is the final 1sec interpolated data set.

7.15 GIS Applications

Evangelos Alevizos & Florian Gausepohl

Many tasks were implemented in GIS environment in order to visualize and assess the data easily and efficiently. GIS provided means for optimization of data collection by allowing distance measurements and survey planning in a straightforward way. Finally GIS assisted the post-processing of data and the production of final maps. A general description of the overall workflow performed in GIS is illustrated in Figure 7.14.1. Three different GIS software packages (SAGA GIS, ArcGIS and Q-GIS) were used generally.

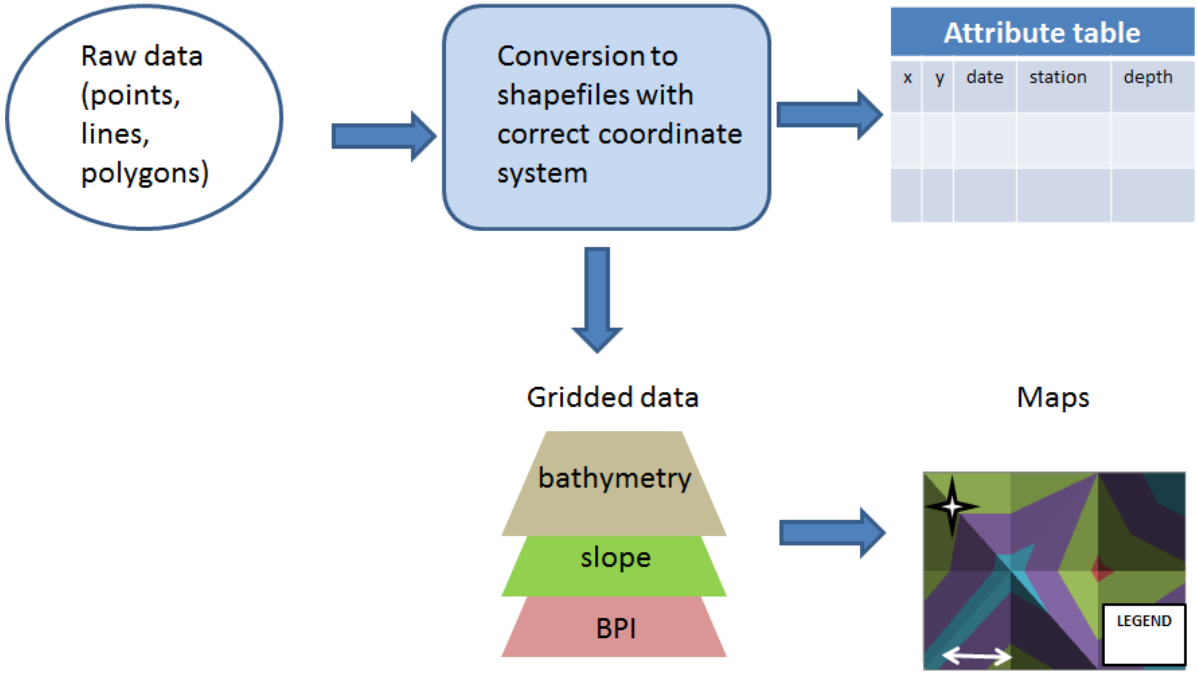


Figure 7.15.1: Work flow diagram showing the production line followed in GIS regarding the data of this cruise.

Station logging

The position data regarding all gear deployments were imported in ArcGIS as simple ASCII files for building the database. In particular all stations were compiled into a point shapefile with associated information written in the attributes table. The organization of data in a structure where all necessary descriptive information about the deployments (time, no of gears, duration, coverage...) is incorporated, will provide a helpful metadata-set for assisting future work.

Bathymetric and sidescan data processing

Regarding quality control and post-processing of the hydroacoustic data SAGA and Arc were used. Initially the known positions of the landers on the seafloor allowed precise georeferencing of the side-scan sonar mosaics where the lander was visible. Processed bathymetry data from the ship and the AUV were imported in ArcGIS for producing an interpolated raster. First raw data were imported and assigned with the appropriate coordinate system. ArcGIS provides an extensive list of various geographical and projected coordinate systems and user-friendly tools in order to ascribe them to the data, we used WGS 84 as geographical coordinate system and UTM Zone 16S for projections. One of the main tasks was to generate continuous surfaces from raw point data. For this we performed spatial interpolation using the Inverse Distance Weighted Algorithm. SAGA GIS was also

used for the production of the bathymetric derivatives such as the slope, the Bathymetric Position Index (BPI) for different scales and shaded relief of the bathymetric surface. Then this datasets were exported as ASCII grids.

Map plotting

Apart from data processing ArcGIS was utilized for making annotated maps that assist planning and management of data collection strategy. ArcGIS provides the user with an intuitive graphic interface where processed data can be transformed into meaningful maps. The final maps produced on board included indication of the scale in meters or kilometers and a frame with the coordinates in decimal degrees at certain intervals for improved interpretation and utility from other users.

7.16 Geochemical Analyses

M. Haeckel, M. Dibbern, G. Schüssler, J. Drescher, S. Paul, I. Preuss, T. J. Suhrhoff, H. de Stigter

Onboard, the collected porewater samples were analysed for their content of dissolved O_2, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_4^{4-}, Fe^{2+}, and total alkalinity (GEOMAR). GEOMAR also took sub-samples for further shore-based analyses of the DIC content and its $\delta^{13}C$ signature, dissolved metal cations, SO_4^{2-}, Br^-, Cl^-, and I^- concentrations, isotopic ratios of Sr, Li, H, and O in the porewater as well as porosity, carbonate, POC, PON, and total sulfur content. NIOZ sub-sampled the sediment for radioisotope analyses (^{210}Pb, ^{234}Th, ^{137}Cs) and grain size distribution. In addition, JUB collected porewater subsamples for DOC, Mn(II/III) speciation, and trace metal – including REY – analyses in their home laboratory as well as samples for amino acids and N-isotope analyses to be carried out at the University of Hamburg. During Leg 2, the group from MPI-Bremen also sub-sampled sediment from 3 gravity cores for microbial analyses, such as cell counts, DNA (bacterial community identification), and enzyme activity. See Table 7.14.2 for a complete list.

Sediment and porewater sampling

Surface and subsurface sediment samples were retrieved using a multiple corer (MUC) that was occasionally deployed video-guided (TV-MUC), a gravity corer (GC), and a box corer (BC; subsampled with MUC liners). After core retrieval, the GC cores were cut in 1-m segments that were then cut in half and the working half was transferred to the ship's cold room (4-6 °C); MUC cores were directly brought into the cold room. The sediment was extruded out of the MUC plastic liners with a piston under oxygen-free, argon atmosphere in a glove bag.

For porewater extraction by means of a low pressure-squeezer (GEOMAR), the MUC sediment was cut into 0.5 to 2 cm thick slices, whereas from the GC working half 3 cm thick slices were sampled based on visual inspection of the cores, generally leading to intervals of approximately 20-40 cm, outside the glovebag, but wrapped in Parafilm to minimize exposure to air. Subsequently, the porewater was extracted in a glovebag under oxygen-free, argon gas atmosphere using a low pressure-squeezer (argon at 3-5 bar, sometimes up to 7 bar). While squeezing, the porewater was filtered through 0.2 µm regenerated cellulose Whatman filters and collected in recipient vessels.

About 5 ml of wet sediment of each sediment slice was collected for porosity, carbonate and CNS element analyses at home. Aliquots of the extracted porewater were sub-sampled for various onboard and further shore-based analyses (Table 7.14.2). Subsamples for ICP-AES analysis were acidified with 30 µl of concentrated suprapure HNO_3 per 3 ml of porewater sample (i.e. pH<1) and

~1.9-ml subsamples for DIC and its $\delta^{13}C$ were treated with 10 µl of $HgCl_2$ to inhibit further microbial degradation. Subsamples (3-5 g) for radiogenic isotope analyses of the sediments were taken from the squeeze cakes after porewater extraction. All samples for home-based analyses were stored refrigerated.

For porewater extraction using a centrifuge (JUB), MUC sediment slices of 2 cm thickness were transferred into 50 mL acid-cleaned centrifuge tubes in the glovebag under a steady flow of argon gas and centrifuged for 40 min at 3,200 rpm. GC sediment was sampled after eye inspection at approximately 30 cm to 1 m intervals. 5-10 cm thick slices of sediment were subsampled into 50 mL acid-cleaned centrifuge tubes. After centrifugation, the porewater was filtered through a 0.2 µm acid-cleaned cellulose acetate filter, again in a glove bag under a steady stream of argon gas. Subsamples for DOC, Mn(II/III) speciation, and trace metal – including REY – analyses were taken. Three MUCs were also sampled for amino acid and N-isotope analyses using rhizon samplers with an average pore size of 0.1 µm. Mn(II/III) speciation as well as amino acid and N-isotope samples were stored at -20 °C, whereas samples for DOC and trace metal analyses were acidified to pH 2 and kept refrigerated. Part of the centrifuged sediments was stored refrigerated for home-based analyses of the solid phase trace metal and REY content. This will be done by pressure digestion and subsequent analyses with ICP-OES and ICP-MS. In total, sediment samples from 5 TV-guided MUC, 3 unguided MUC, 1 BC, and 7 GC deployments was collected for porewater and sediment analysis (Table 7.14.2).

Porewater analyses

Analyses for the porewater solutes NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_4^{4-}, and Fe^{2+} were completed onboard using a Hitachi UV/VIS spectrophotometer. The respective chemical analytics followed standard procedures (Grasshoff et al., 1999), i.e. nitrite and nitrate (after reduction with Cd) were measured as sulphanile-naphthylamide, ammonium was measured as indophenol blue, phosphate and silicate as molybdenum blue, and iron with ferrospectral. The total alkalinity of the porewater was determined by titration with 0.02 N HCl using a mixture of methyl red and methylene blue as indicator. The titration vessel was bubbled with argon to strip any CO_2 produced during the titration. The IAPSO seawater standard was used for calibration.

Ex situ O_2 microprofiling

Oxygen concentration-depth profiles were measured in the ship's cold room (4-6 °C) by lowering fibre-optic oxygen microsensors (FireStingO2 optodes from Pyroscience GmbH, Aachen) into the sediment of a MUC liner (Fig. 7.14.1). A computer-controlled, motorized micro-manipulator was used to move the optodes downwards in step-sizes of 500 µm. The optodes were allowed to equilibrate for 5 s at each depth before the signal was recorded. Since the micro-manipulator is only capable of driving a distance of 7.6 cm, the optodes were kept manually in place when this depth was reached while the micro-manipulator moved back into its start position. Then the optodes were fixed to the micro-manipulator again and lowered further into sediment for another 7.6 cm. This procedure was repeated until, at least, the depth of O_2 depletion was detected. 2 optodes were mounted to a steel rod allowing 2 parallel O_2 profiles to be recorded at the same time. Typically, 2-3 complete profile runs were conducted to produce 4-6 O_2 concentration depth-profiles.

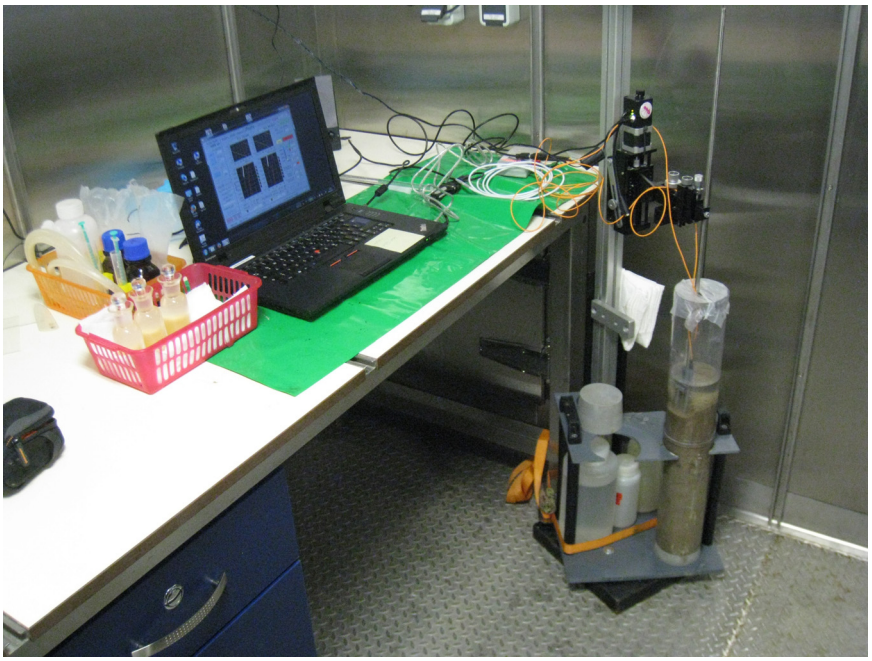


Figure 7.16.1: Setup for ex situ O_2 micro-profiling of MUC sediments in the ship's cold room.

The optodes were calibrated using oxygenated and oxygen-depleted (by bubbling with argon gas for 30 min) 3.5 % NaCl solution. The dissolved O_2 concentrations of both solutions were determined by Winkler titration (Grasshoff et al., 1999) at the beginning and the end of the cruise (no significant difference was observed). In addition, the O_2 content of the overlying bottom water in each of the MUC liners was also determined by Winkler titration with 3 replicates. The analytical precision and accuracy of each method are given in Table 7.14.1.

Table 7.16.1: Analytical methods of onboard geochemical analyses.

Parameter	Method	Detection limit	Precision	Accuracy
Fe^{2+}	Photometer	1 µmol/l	3 %	-
NO_3^-, NO_2^-	Photometer	0.5 µmol/l	3 %	-
NH_4^+	Photometer	1 µmol/l	5 %	-
PO_4^{3-}	Photometer	1 µmol/l	5 %	-
SiO_4^{4-}	Photometer	5 µmol/l	2 %	-
Alkalinity	Titration	0.05 meq/l	3 %	4 %
O_2	Winkler titration	0.2 µmol/l	1 %	1 %
	Optode microprofiles	1 µmol/l	1 %	-

Table 7.16.2: List of sampled cores and collected sub-samples.

Station	**Area**	**Latitude (S)**	**Longitude (W)**	**Water depth [m]**	**PW**	**Porosity / CNS**	**IC**	**ICP-AES / $^{87/86}Sr$**	**DIC / $\delta^{13}C_{DIC}$**	**Iso PW**	**Iso Sed**	**O_2**	**micro bio**	**DOC**	**Mn / trace metal**	**AA / N-iso**	**Core length / cm** GEOMAR / JUB	**No. samples** GEOMAR / JUB
34 MUC 6	Reference S	7°07.524'	88°27.031'	4162	X	X	X	X	X	X	X	X		X	X		27 / 27.5	15 / 13
38 GC 1	Reference S	7°07.537'	88°27.047'	4161	X	X	X	X	X	X	X			X	X		917	28 / 13
51 GC 2	DEA-W plough marks	7°04.411'	88°27.836'	4148	X	X	X	X	X	X	X			X	X		978	28 / 16
56 TV-MUC 12	DEA-W inside plough marks	7°04.414'	88°27.760'	4149	X	X	X	X	X	X	X	X		X	X	X	28 / 31 (AA: 27.5)	19 / 15 (AA: 6)
61 TV-MUC 13	DEA-W next to plough marks	7°04.378'	88°27.781'	4148	X	X	X	X	X	X	X	X		X	X		35 / 33	20 / 17
70 TV-MUC 17	DEA-W next to plough marks	7°04.400'	88°27.778'	4128	X	X	X	X	X	X	X	X		X	X		26 / 24.5	18 / 12
74 TV-MUC 20	DEA-E black patch sidescan	7°03.945'	88°27.097'	4150	X	X	X	X	X	X	X	X		X	X		36 / 33	21 / 16
80 MUC 22	Reference W	7°04.542'	88°31.581'	4130	X	X	X	X	X	X	X	X		X	X	X	22.5 / 24 (AA: 16)	18 / 13 (AA: 5)
84 GC 3	DEA-E black patch sidescan	7°03.951'	88°27.093'	4146	X	X	X	X	X	X	X		X	X	X		947	31 / 17
89 GC 4	Reference W	7°04.562'	88°31.577'	4125	X	X	X	X	X	X	X			X	X		958	28 / 11
100 GC 5	DEA trough	7°04.342'	88°27.442'	4151	X	X	X	X	X	X	X		X	X	X		878	27 / 14
108 TV-MUC 26	DEA-E inside plough marks	7°04.483'	88°26.919'	4169	X	X	X	X	X	X	X	X		X	X	X	40 / 35.5 (AA: 30)	21 / 18 (AA: 5)
119 MUC 31	Reference E	7°06.033'	88°24.826'	4204	X	X	X	X	X	X	X	X		X	X		33 / 33	19 / 17
123 GC 6	Reference E	7°06.045'	88°24.848'	4208	X	X	X	X	X	X	X		X	X	X		921	29 / 16
129 BC 26	Crater small volcano	7°03.373'	88°26.026'	4144	X	X	X	X	X	X	X			X	X		35 / 34	20 / 17
132 GC 7	Crater small volcano	7°03.369'	88°26.031'	4152	X	X	X	X	X	X	X			X	X		936	29 / 12

GC = gravity corer; MUC = (TV-guided) multiple-corer; BC = box corer (subsampled with MUC liner); PW = porewater analyses of TA, NO_3^-, NO_2^-, NH_4, PO_4, SiO_4; IC = ion chromatography (SO_4, Br, Cl, I); ICP-AES = inductively-coupled atomic emission spectroscopy (for various dissolved cations); $^{87/86}Sr$ = radiogenic Sr isotope ratio in porewater; Iso PW = O, H, Li isotope ratios of porewater; Iso Sed = ^{210}Pb, ^{234}Th, ^{137}Cs isotope ratios of sediment; O_2 = ex situ oxygen microprofiling; microbio = sediment for cell counts, DNA, bacteria, enzyme activity; DOC = dissolved organic carbon; Mn / trace metals = porewater Mn(II/III) and trace metals; AA / N-iso = amino acids and $\delta^{15}N$ of the porewater.

8. Preliminary Results

8.1 Seafloor Mapping

8.1.1 AUV Abyss Mission Summaries

Marcel Rothenbeck, Anja Steinführer, Lars Triebe, Emanuel Wenzlaff

During cruise SO242-1 seventeen missions were flown by Abyss (Table 8.1.1.1; Figure 8.1.1.1). The missions were flown using the multibeam, camera or sub-bottom configuration. Primary sensors were the RESON Seabat 7125 (multibeam; 200 kHz; 4 missions), the electronic still camera (10 missions), the Edgetech sidescan sonar (120 kHz; 7 missions) and the sub-bottom profiler (2 missions). The following table shows an overview of the missions done on this cruise.

Table 8.1.1.1: AUV Mission Statistics for cruise SO242/1. Survey time = time spent mapping on the seafloor; Mission time = time including descent, survey and ascent phase; Distance travelled = total distance during mission; MB = Multibeam Echo Sounder; SSS = Sidescan Sonar.

Station	Area	Dive #	Date 2015	Survey time	Mission time	Distance travelled	Sensors	Comment
242/1_#15		187	July 31	-	0.1 h	0.8 km	(aborted)	-
242/1_#18	DEA	188	July 31	10.3 h	14.5 h	72.2 km	SSS (120 kHz) / Camera test	no images 69 jsf raw files
242/1_#25	DEA	189	August 1	9.3 h	12.5 h	63.7 km	SSS (120 kHz) / Camera test	3,140 good images 57 jsf raw files
242/1_#33	DEA	190	August 2	10.1 h	14.1 h	72.1 km	SSS (120 kHz) / Camera	7,450 good images 60 jsf raw files
242/1_#41	Southern Ref	191	August 4	9.6 h	12.9 h	64.3 km	SSS (120/410 kHz) / Camera	1,274 good images 41 jsf raw files
242/1_#47	DEA	192	August 5	11.3 h	15.5 h	83.8 km	MB (200 kHz)	187 s7k raw files
242/1_#60	DEA	193	August 6	9.6 h	12.9 h	70.6 km	MB (200 kHz)	42 s7k raw files
242/1_#69	N off DEA	194	August 11	9.0 h	12.5 h	68.3 km	MB (200 kHz)	43 s7k raw files
242/1_#75	NE off DEA	195	August 12	8.3 h	12.2 h	66.4 km	MB (200 kHz)	41 s7k raw files
242/1_#83	DEA	196	August 13	9.8 h	14.1 h	70.4 km	Camera	34,200 good images
242/1_#88	DEA / OFOS track	197	August 14	9.6 h	13.0 h	65.0 km	Camera	34,250 good images
242/1_#94	DEA / South off DEA	198	August 15	11.4 h	14.6 h	75.3 km	SSS (120 kHz) / Camera	23,782 good images 32 jsf raw files
242/1_#102	DEA / South off DEA	199	August 16	9.3 h	12.7 h	64.4 km	Camera	20.790 good images
242/1_#107	DEA / NW off DEA	200	August 17	6.8 h	10.7 h	54.8 km	Camera	24,940 good images
242/1_#113	Southern Ref	201	August 19	9.7 h	13.4 h	65.7 km	Camera	17,890 good images
242/1_#118	NE off DEA	202	August 20	13.3 h	17.0 h	91.8 km	SSS (120 kHz) / SBP test	53 jsf raw files (SBP) 51 jsf raw files (SSS)
242/1_#125	DEA / East off DEA	203	August 21	10.3 h	13.8 h	74.9 km	SSS (120 kHz) / SBP	51 jsf raw files (SBP) 20 jsf raw files (SSS)
			Total:	**157.7 h**	**216.5 h**	**1124.5 km**		

The AUV required in total 36.75 hours of ships time. The main part of this time was consumed during transponder calibration, monitoring the descent phase of the first dive and recovering of the transponders. in total the AUV brought in this way 9.5 additional ships days (related to the water

time of the AUV: 262 hours) or 7.5 additional ship days (related to the mission time as shown in the table above).

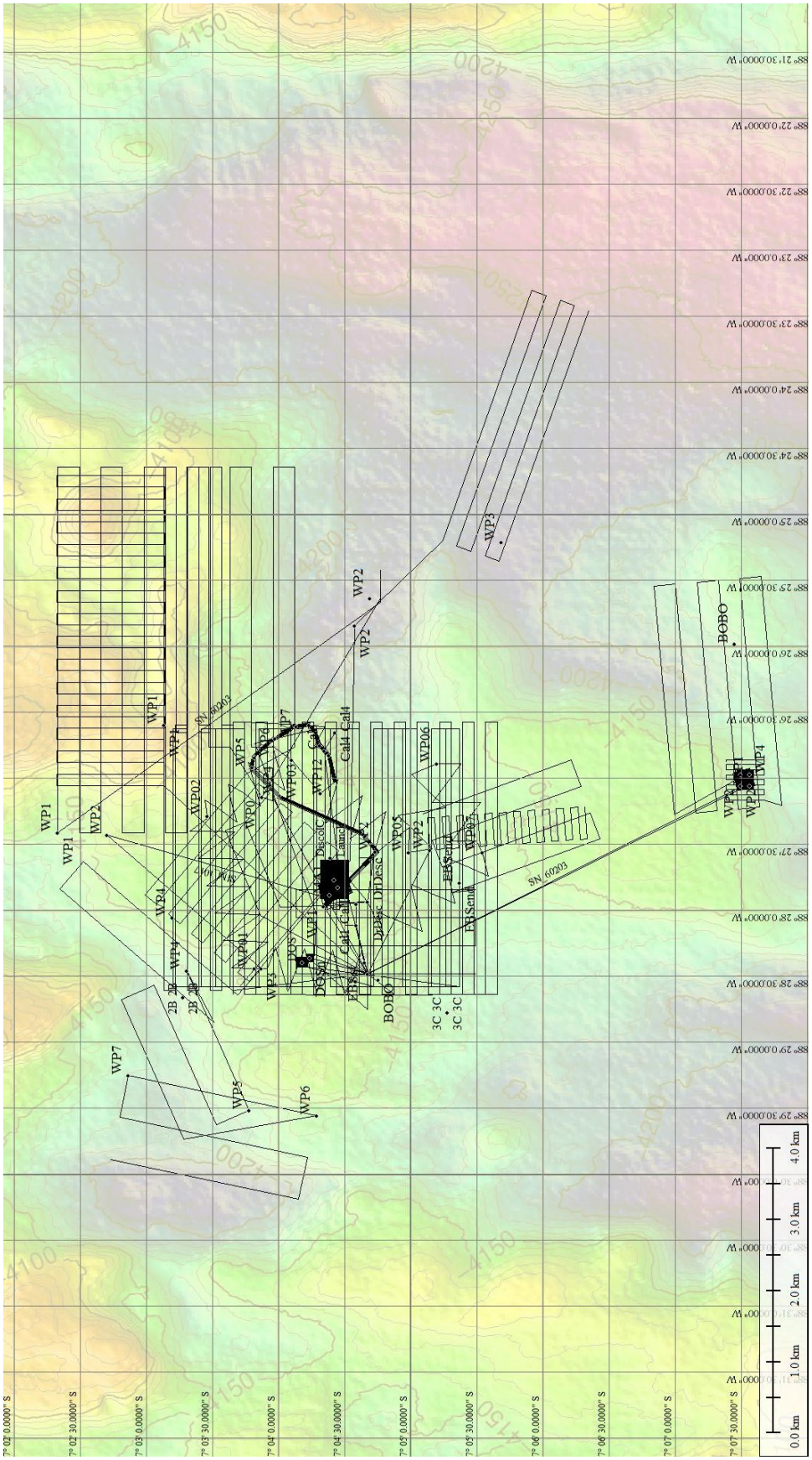


Figure 8.1.1.1: Tracks of each dive done on cruise SO242-1

Station 242/1_3-1; 5-1; 9-1; 10-1 / Transponder deployment /Area DEA
Station 242/1_13-1 / Transponder calibration survey /Area DEA

Four Long Baseline (LBL) transponder were set around the DEA area. The ship drove large circles around the transponder drop positions for the calibration of the transponders. The calibration took 5.6 hours including transit time. The positions were calculated by the software "Survey" (Hydroid). Positions of the LBL transponders. Transponder 4C couldn't be recovered during SO242/1. The reason was not known at the end of SO242/1 but it turned out that the glass flotation spheres imploded.

Transponder	Longitude	Latitude
1A	88° 26.762'' W	07° 3.377" S
2B	88° 28.661'' W	07° 3.274" S
3C	88° 28.777'' W	07° 5.273" S
4C	88° 26.766'' W	07° 5.349" S

Station 242-1_15-1 / Dive Abyss0187 /Area DEA

Mission 187 was aborted manually due to weight issues of the vehicle. The AUV was too light weighted to be able to dive. It was brought on deck to add weights inside. The planned mission was done during dive 180.

Station 242-1_18-1 / Dive Abyss0188 / Area DEA

Date: 31st July 2015 Launch: 18:02 UTC Recovery: 11:29 UTC
Survey time: 10.33 hours Distance travelled: 72.2 km
Sensors: Sidescan Sonar 120 kHz, Electronic Still Camera (Test, Canon 6D)

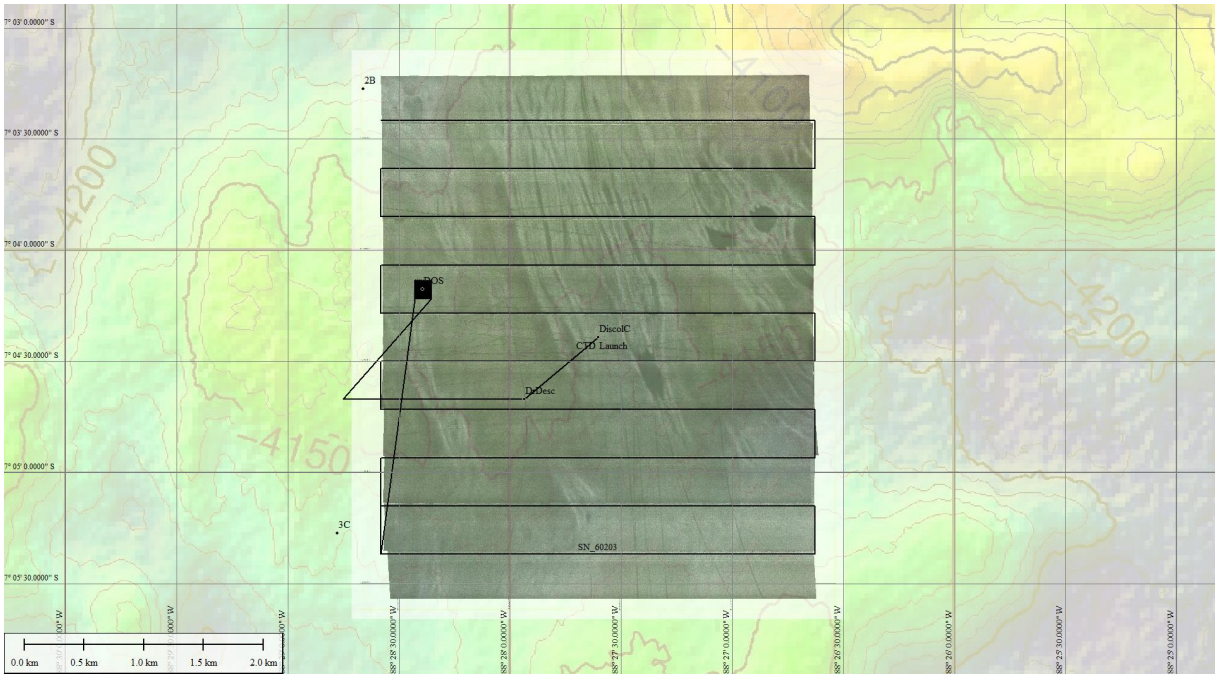


Figure 8.1.1.2: Dive plan of mission 187.

Mission 188 was supposed to map the working area (Sidescan sonar) and to get an overview of the tracks of the plough which have been done in former DISCOL cruises. Figure X.X shows a bunch of these tracks. Dive 188 was done in camera configuration. The vehicle dived during the survey in depth between 4060 and 4130 meters. The mission started with a camera survey above estimated DOS lander position before the primary sidescan survey begun. Unfortunately the camera wasn't working properly and no picture was made. The photo survey pattern was redone in mission 189.

The sidescan survey pattern was programmed with settings shown in the box below. The vehicle covered an area of 15.48 km^2 (average coverage of 2.0 km^2/hour).

Figure 8.1.1.3: Tracks shown in the sidescan mosaic.

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	400 m
Total amount of SSS raw files:	69				
Designation of used SSS raw files:	DATA0000085 - DATA0000153				

Station 242-1_25-1 / Dive Abyss0189 / Area DEA

Date:	1st August 2015	Launch: 17:09 UTC	Recovery: 09:49 UTC
Survey time:	9.28 hours	Distance travelled: 63.7 km	
Sensors:	Sidescan Sonar 120 kHz, Electronic Still Camera (Canon 6D)		

Mission 189 was supposed to redo the sidescan survey that was done in dive 188 with half of the altitude and half of the sidescan range to achieve a higher resolution. The small photo survey pattern above the DOS lander was also redone since the camera didn't work during dive 188.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1 Hz
Vehicle speed:	3.0 knots	Altitude:	7 m	Line spacing:	8 m

Total amount images:	13,000
Designation of good images:	SO242-1_025_AUV3 Identifier 4320-7460

The vehicle flew in camera configuration. It dived during the sidescan survey in depths between 4105 and 4155 meters. The first two legs in the middle of the pattern area was programmed to allow continuous LBL supported navigation. The vehicle could not calculate even one LBL fix since it was getting ranges only from transponder 3C. It was covered an area of 8.17 km^2 during the sidescan survey. That means an average coverage of 1.1 km^2/hour with settings as shown in the box below.

Sidescan frequency:	120 kHz	Range:	200 m		
Vehicle speed:	3.0 knots	Altitude:	20 m	Line spacing:	200 m
Total amount of SSS raw files:	57				
Designation of used SSS raw files:	DATA0000154 - DATA0000210				

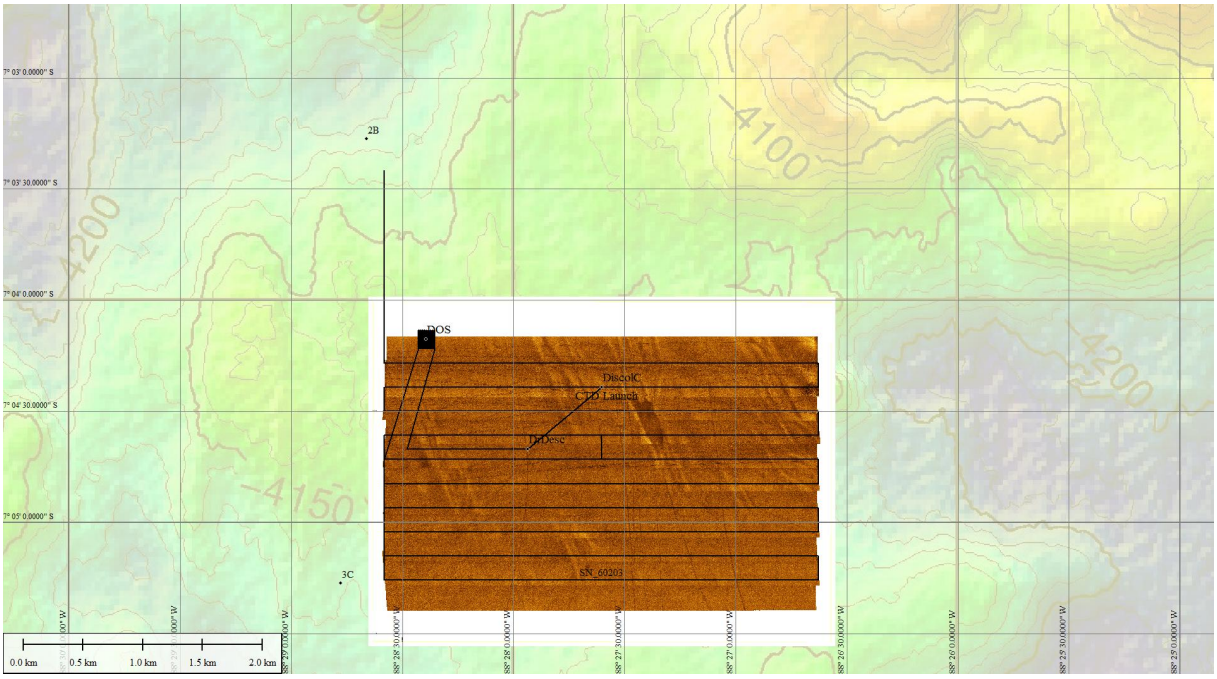


Figure 8.1.1.4: Dive plan of mission 189

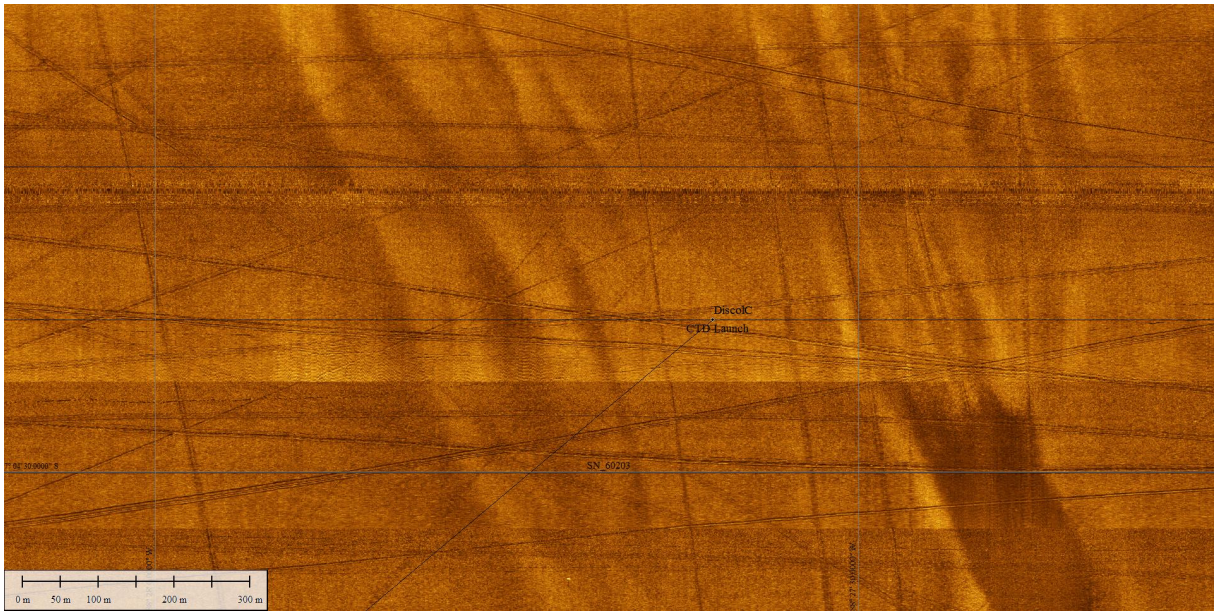


Figure 8.1.1.5: Tracks shown in the sidescan mosaic (sidescan range: 200 m)

Station 242-1_33-1 / Dive Abyss0190 / Area DEA

Date:	2nd August 2015	Launch: 19:17 UTC	Recovery: 13:05 UTC
Survey time:	10.1 hours	Distance travelled: 72.1 km	
Sensors:	Sidescan Sonar 120 kHz, Electronic Still Camera (Canon 6D)		

Mission 190 was supposed to finish the sidescan map of dive 189 and to do photo tests above the DOS lander in the western part of the DEA. The vehicle flew in camera configuration.

The photo survey pattern was moved to a corrected DOS lander position. The vehicle repeated the survey pattern in diverse heights as shown in the box below. The DOS lander was photographed in several orientations.

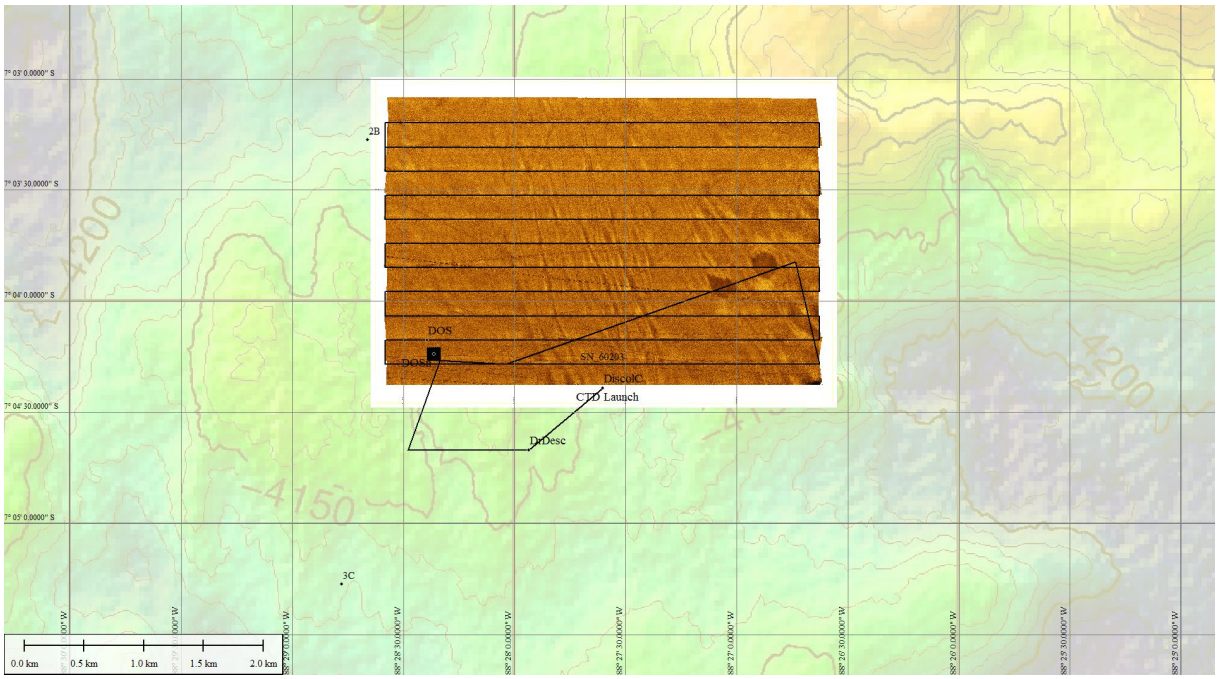


Figure 8.1.1.6: Dive plan of mission 190.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	6/8/10/7 m	Line spacing:	8 m

Total amount images:	13,000
Designation of good images:	SO242-1_033_AUV4 Identifier 3190-10640

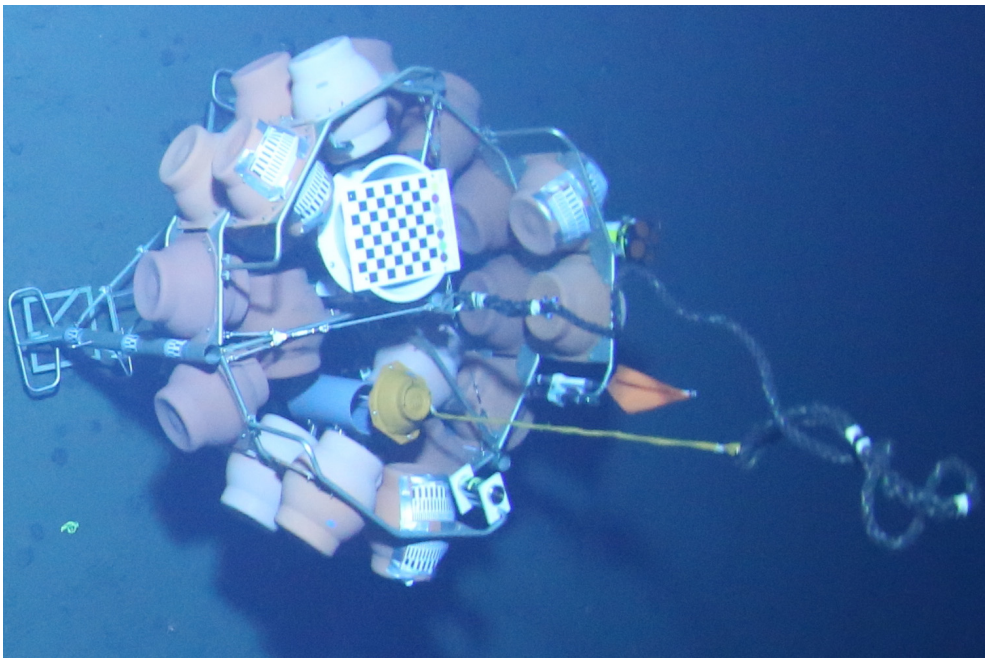


Figure 8.1.1.7: The DOS-lander as phot target.

The vehicle dived during the sidescan survey in depth between 4030 and 4150 meters. The covered plain had an area of 8.52 km^2 in total which means an average coverage of 1.1 km^2/hour with settings as shown in the box below.

Sidescan frequency:	120 kHz	Range:	200 m		
Vehicle speed:	3.0 knots	Altitude:	20 m	Line spacing:	200 m
Total amount of SSS raw files:	60				
Designation of used SSS raw files:	DATA0000211 - DATA0000270				

Station 242-1_41-1 / Dive Abyss0191 / Southern reference area

Date:	4th August 2015	Launch: 00:37 UTC	Recovery: 15:23 UTC
Survey time:	9.6 hours	Distance travelled: 64.3 km	
Sensors:	Sidescan Sonar 120 / 410 kHz, Electronic Still Camera (Canon 6D)		

Mission 191 was again a combined photo/sidescan mission (camera configuration). I was supposed to gather pictures for a complete photo mosaic of the southern reference area and to map this area (extended to the east) by sidescan. The sidescan should include the BOBO lander and the track of the EBS that was done next to the lander.

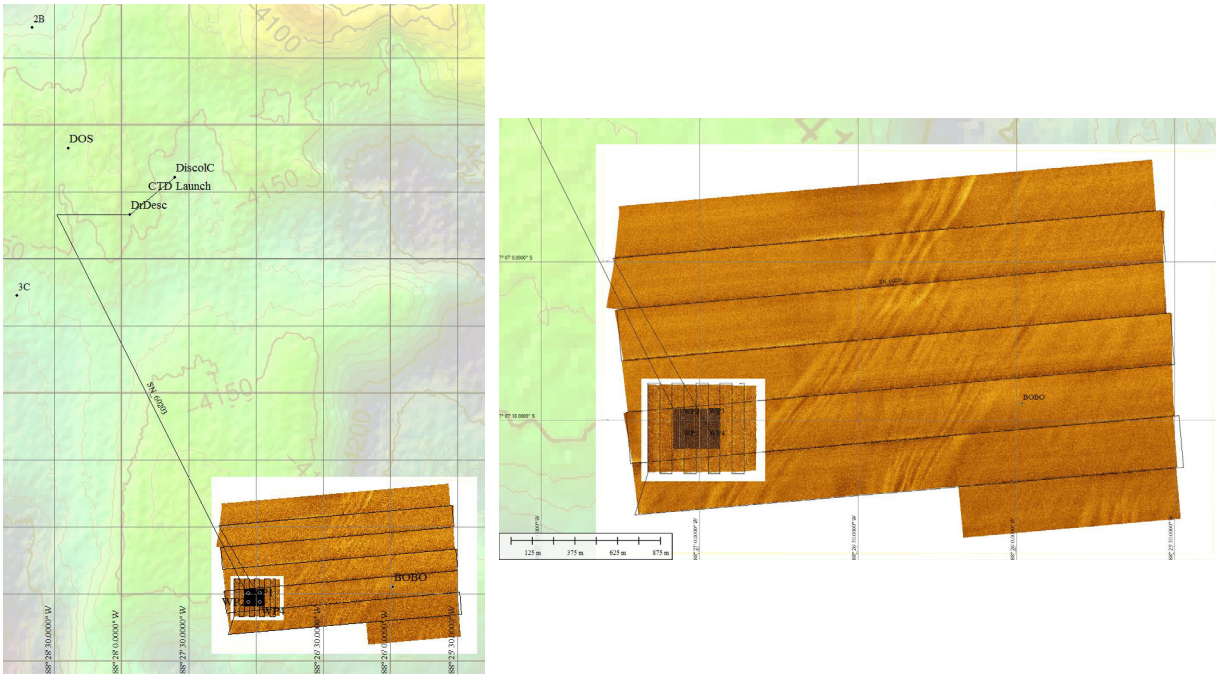


Figure 8.1.1.8: Dive plan of mission 191.

The photo survey was done in the following settings:

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	7 m	Line spacing:	5 m

Total amount images:	3,274
Designation of good images:	SO242-1_041_AUV5 Identifier 2000 - 3274

The Canon camera broke during the photo survey and only half of the reference area could be covered. The shutter blades of this camera was disassemble to avoid broken blades. The shown error was the same one than seen with broken blades.

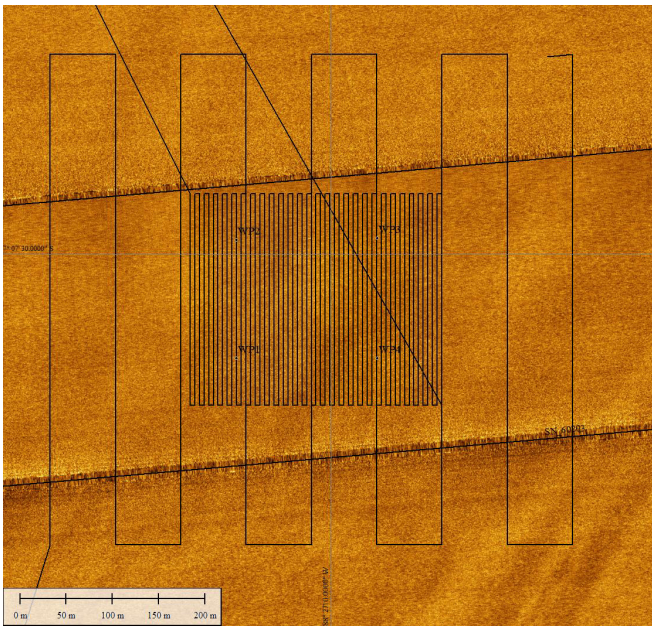


Figure 8.1.1.9: Photo survey pattern (middle) and sidescan survey pattern (410 kHz).

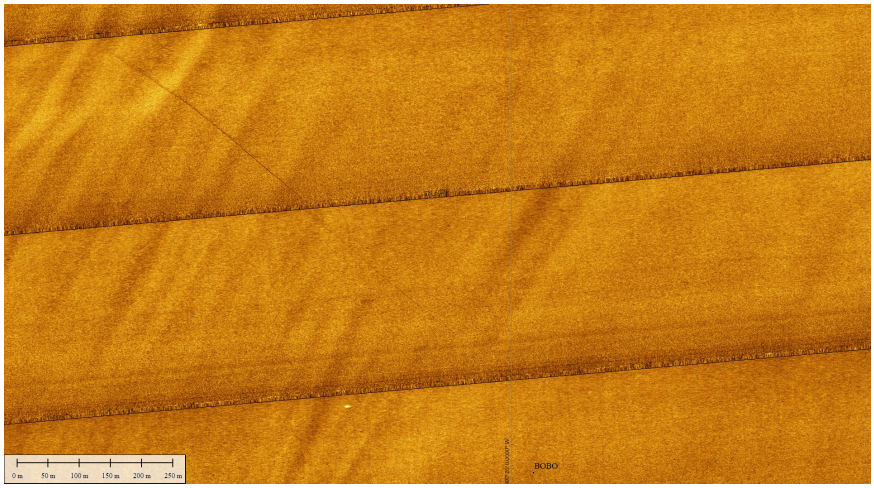


Figure 8.1.1.10: Position of the BOBO lander and the EBS track.

The vehicle dived during the sidescan surveys in depth between 3650 and 4150 meters. The Doppler velocity log wasn't working during the second half of the last sidescan survey leg and the vehicle came up slowly to avoid bottom contact. The covered plain of the first sidescan survey (120 kHz/ BOBO lander / EBS track / southern reference area) had an area of 6.08 km^2 in total which means an average coverage of 1.48 km^2/hour with settings as shown in the box below.

Sidescan frequency:	120 kHz	Range:	300 m		
Vehicle speed:	3.0 knots	Altitude:	30 m	Line spacing:	300 m

The vehicle covered an area of 0.32 km^2 during the last sidescan survey (410 kHz). This corresponds with an average coverage of 0.31 km^2/hour according the settings shown in the box below.

Sidescan frequency:	410 kHz	Range:	70 m		
Vehicle speed:	3.0 knots	Altitude:	7 m	Line spacing:	70 m

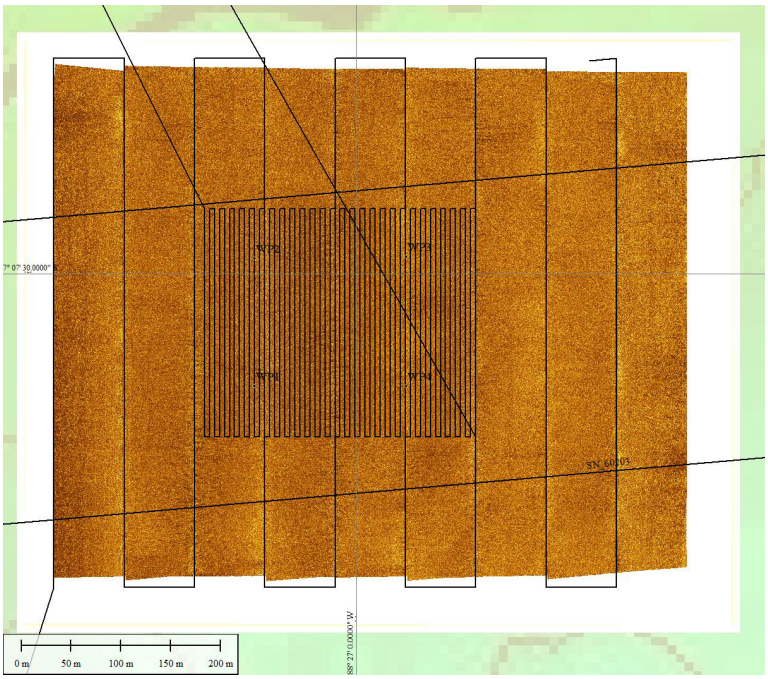


Figure 8.1.1.11: Sidescan map (410 kHz survey).

Total amount of SSS raw files:	41
Designation of used SSS raw files:	DATA0000000 - DATA0000040

The AUV was rebuilt to multibeam configuration after dive 191. The camera inside the camera housing was replaced by a new one (shutter blades inside).

Station 242-1_47-1 / Dive Abyss0192 / Area DEA

Date: 5th August 2015 Launch: 07:50 UTC Recovery: 03:13 UTC
Survey time: 11.27 hours Distance travelled: 83.8 km
Sensors: Reson Seabat 7125 Multibeam Sonar 200 kHz

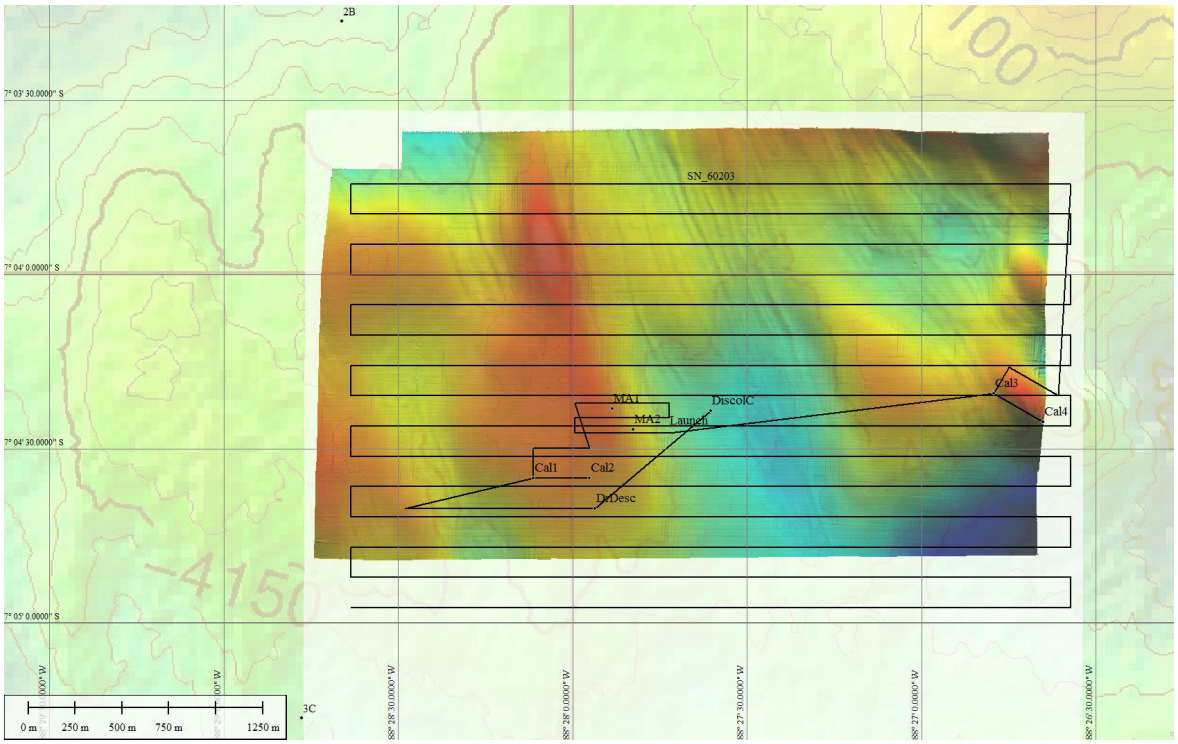


Figure 8.1.1.12: Dive plan of mission 192.

Mission 192 was supposed to do the first part of a multibeam map of the DEA area. It started in the middle of the DEA to prevent interference with sample gears which should deployed in this area after the dive. The dive started with two calibration pattern in different terrain to calculate roll, pitch and heading offsets for the postprocessing. The calculated values showed no difference to the former ones. The vehicle dived in multibeam configuration and covered an area of 7.87 km^2 during the multibeam survey (200 kHz). This corresponds with an average coverage of 0.83 km^2/hour according the settings shown in the box below.

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

Total amount of MB raw files:	187
Designation of used MB raw files:	20150805_110202 - 20150805_230822

The vehicle dived during the survey in depth between 4040 and 4090 meters. The increased amount of raw data was caused be the included compressed image record inside the RESON log data.
During the second to last leg of the pattern the vehicle stopped the survey due to battery power and headed straight to the endpoint to abort the mission.

Station 242-1_60-1 / Dive Abyss0193 / Area DEA

Date:	6th August 2015	Launch: 22:45 UTC	Recovery: 13:32 UTC
Survey time:	9.63 hours	Distance travelled: 70.6 km	
Sensors:	Reson Seabat 7125 Multibeam Sonar 200 kHz		

Mission 193 was supposed to do the second part of the multibeam map of the DEA area. The vehicle dived in multibeam configuration and covered an area of 8.08 km^2 during the multibeam survey (200 kHz). This corresponds with an average coverage of 0.95 km^2/hour according the settings shown in the box below.

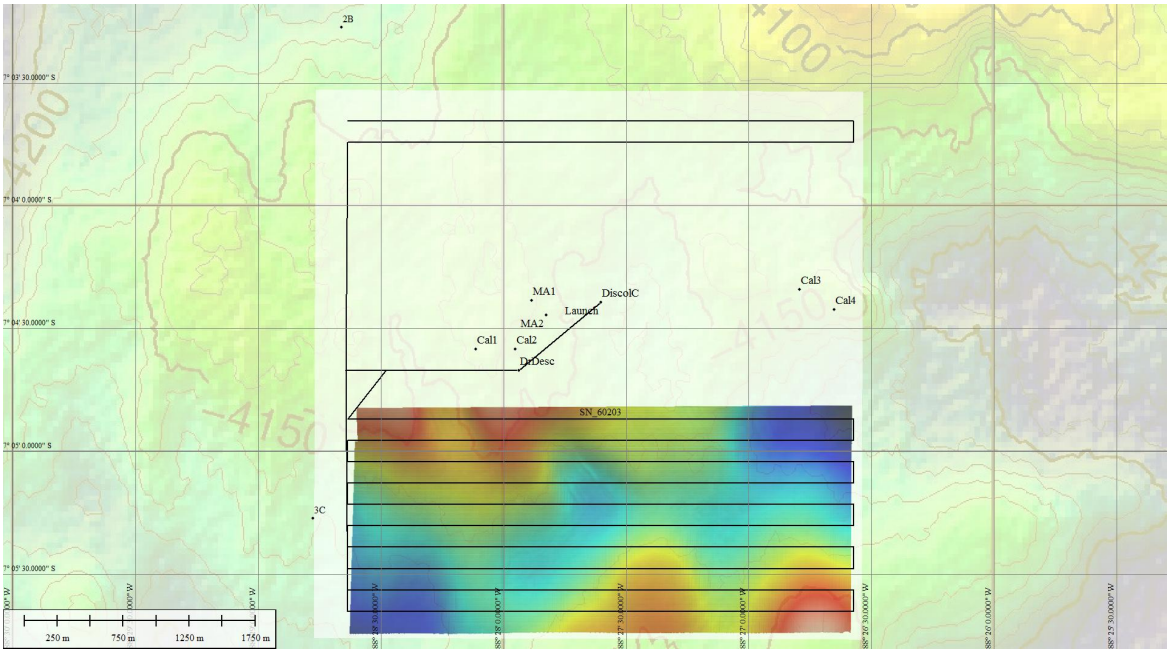


Figure 8.1.1.13: Dive plan of mission 193.

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

Total amount of MB raw files:	42
Designation of used MB raw files:	20150807_004750 - 20150807_113826

The vehicle dived during the survey in depth between 4040 and 4090 meters. The compressed image record wasn't included.

Station 242-1_69-1 / Dive Abyss0194 / North and Northeast off DEA

Date:	11th August 2015	Launch: 10:30 UTC	Recovery: 01:42 UTC
Survey time:	9.02 hours	Distance travelled: 68.3 km	
Sensors:	Reson Seabat 7125 Multibeam Sonar 200 kHz		

Mission 194 was supposed to do extend the multibeam map of the DEA northwards and northeastwards. The vehicle dived in multibeam configuration and covered an area of 8.8 km^2 during the multibeam survey (200 kHz). This corresponds with an average coverage of 0.98 km^2/hour according the settings shown in the box below.

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

Total amount of MB raw files:	43
Designation of used MB raw files:	20150811_124115 - 20150811_223851

The vehicle dived during the survey in depth between 3800 and 4100 meters. The compressed image record wasn't included.

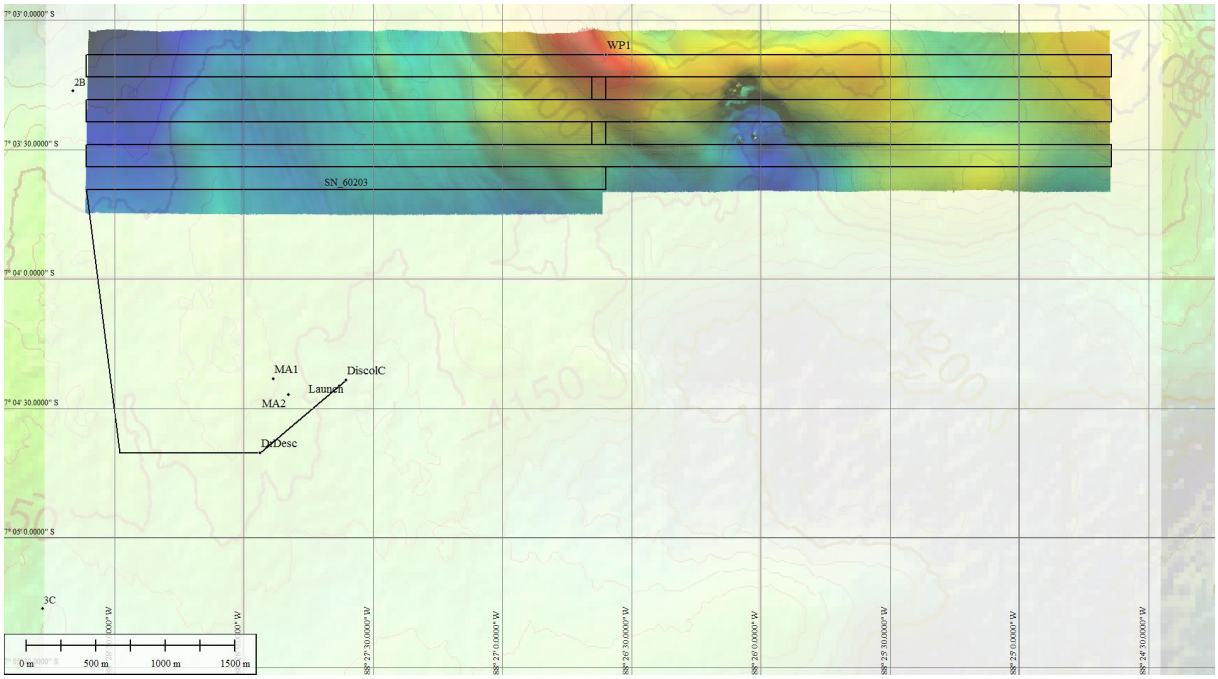


Figure 8.1.1.14: Dive plan of mission 194.

Station 242-1_75-1 / Dive Abyss0195 / Northeast off DEA

Date:	12th August 2015	Launch: 07:28 UTC	Recovery: 00:27 UTC
Survey time:	8.33 hours	Distance travelled: 66.4 km	
Sensors:	Reson Seabat 7125 Multibeam Sonar 200 kHz		

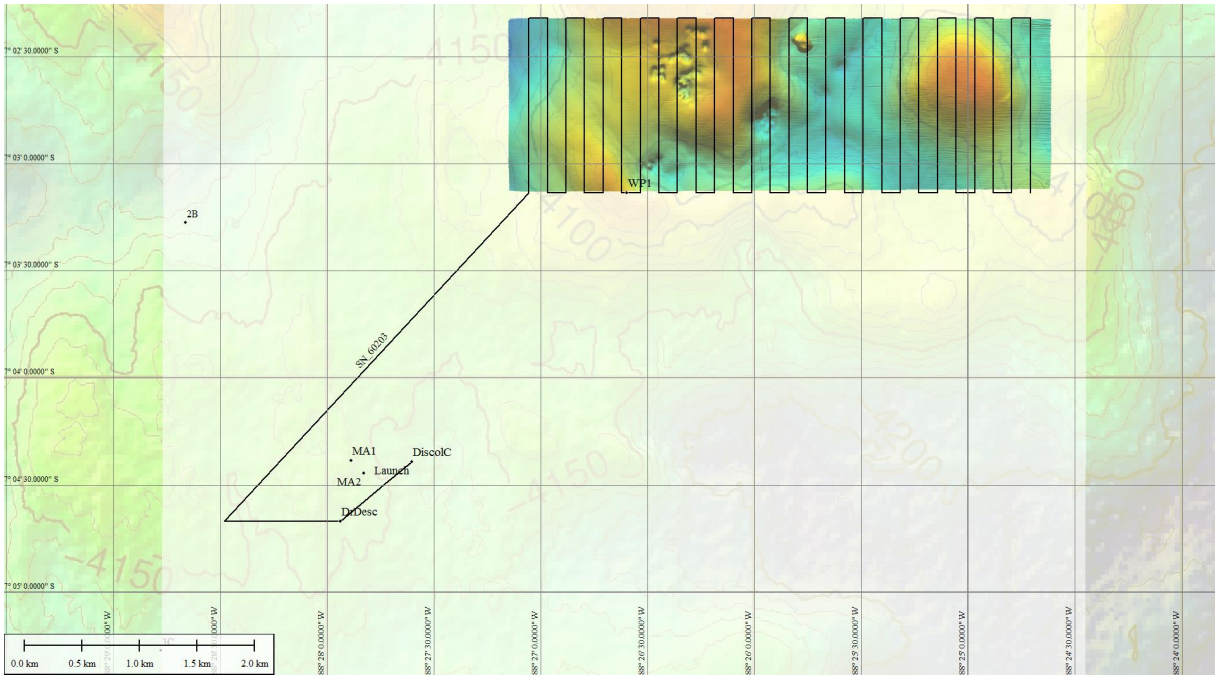


Figure 8.1.1.15: Dive plan of mission 195.

Mission 194 was supposed to do extend the multibeam map of the DEA northeastwards. The vehicle dived in multibeam configuration and covered an area of 6.92 km^2 during the multibeam survey (200 kHz). This corresponds with an average coverage of 0.83 km^2/hour according the settings shown in the box below.

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

Total amount of MB raw files:	41
Designation of used MB raw files:	20150812_100331 - 20150812_192647

The vehicle dived during the survey in depth between 3965 and 4040 meters. The compressed image record wasn't included

Station 242-1_83-1 / Dive Abyss0196 / Area DEA highly disturbed

Date:	13th August 2015	Launch: 20:09 UTC	Recovery: 13:12 UTC
Survey time:	9.75 hours	Distance travelled: 70.4 km	
Sensors:	Electronic Still Camera (Canon 6D)		

Mission 196 was the first only photo mission and was supposed to do a photo mosaic of the central sample area inside the DEA. The vehicle dived in camera configuration and covered an area of 0.21 km^2 during the photo survey. This corresponds with an average coverage of 0.023 km^2/hour according to the settings shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1 Hz
Vehicle speed:	3.0 knots	Altitude:	7.0 m	Line spacing:	5 m

Total amount images:	37,000
Designation of good images:	SO242-1_083_AUV10 Identifier 2800-37000

The vehicle dived during the survey in depth between 4117 and 4140 meters.

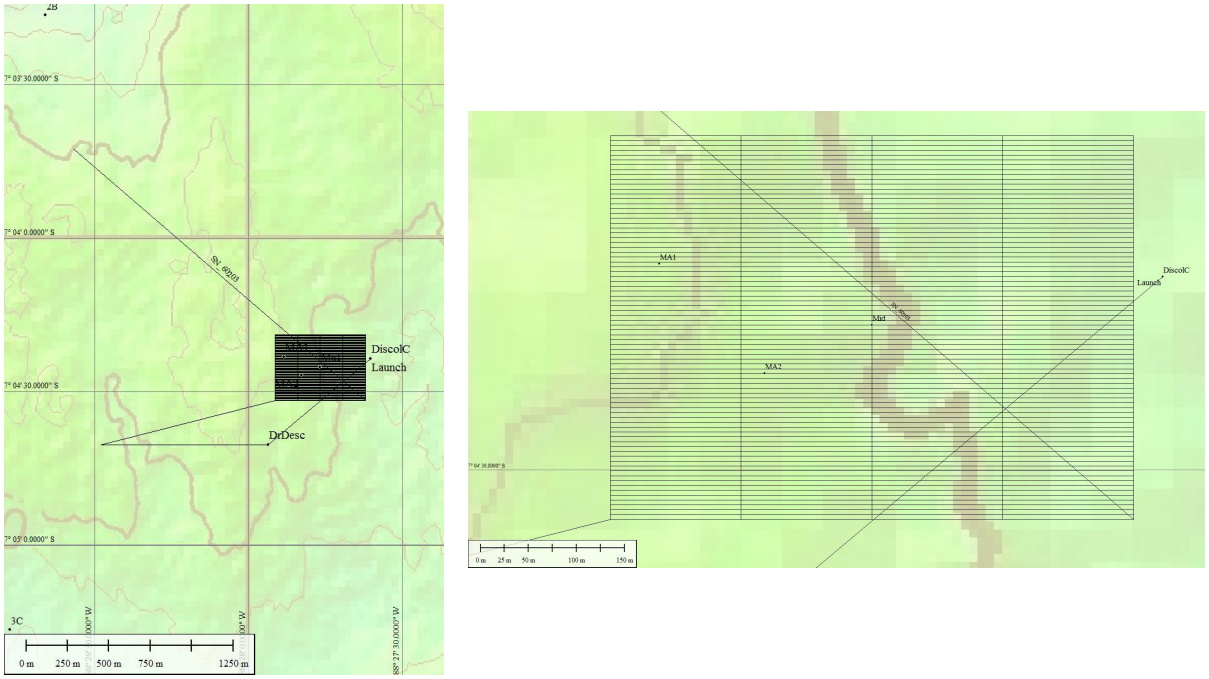


Figure 8.1.1.16: Dive plan of mission 196.

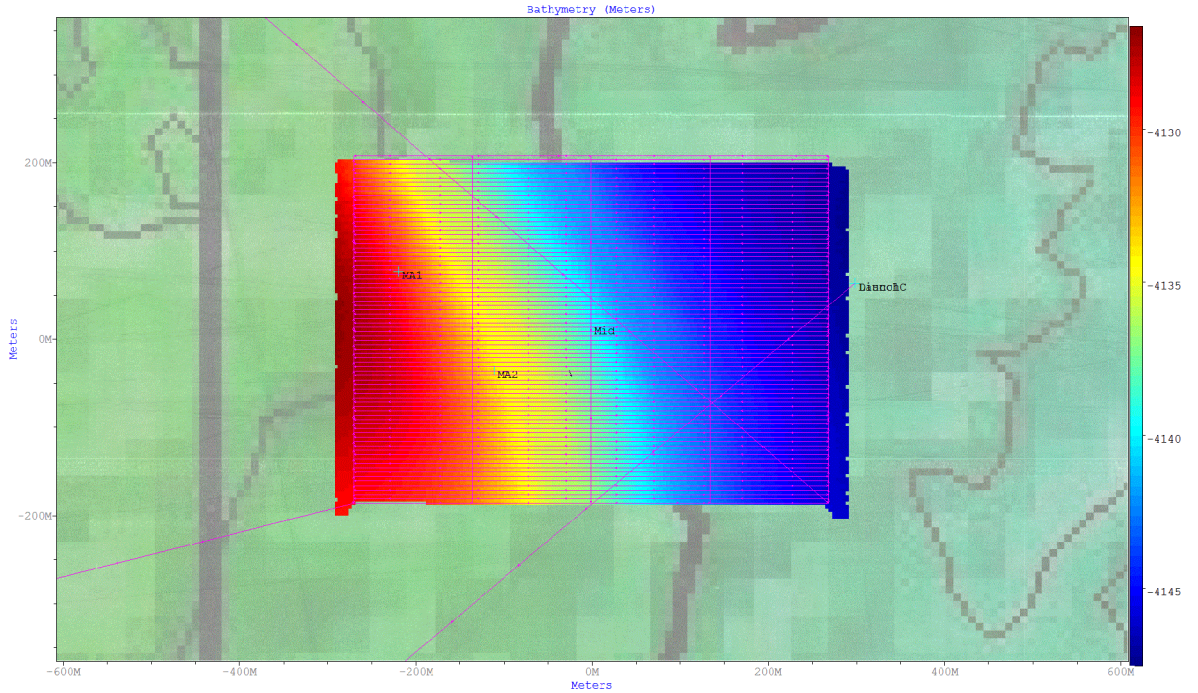


Figure 8.1.1.17: "singlebeam" map of the surveyed area (vehicle altitude + depth).

Station 242-1_88-1 / Dive Abyss0197 / Area DEA (OFOS track)

Date:	14th August 2015	Launch: 21:15 UTC	Recovery: 12:37 UTC
Survey time:	9.62 hours	Distance travelled: 65.0 km	
Sensors:	Electronic Still Camera (Canon 6D)		

Mission 197 was supposed to follow the OFOS track, that was done before, and do photo mosaic boxes above. The vehicle dived in camera configuration. The camera and vehicle settings are shown in the box below.

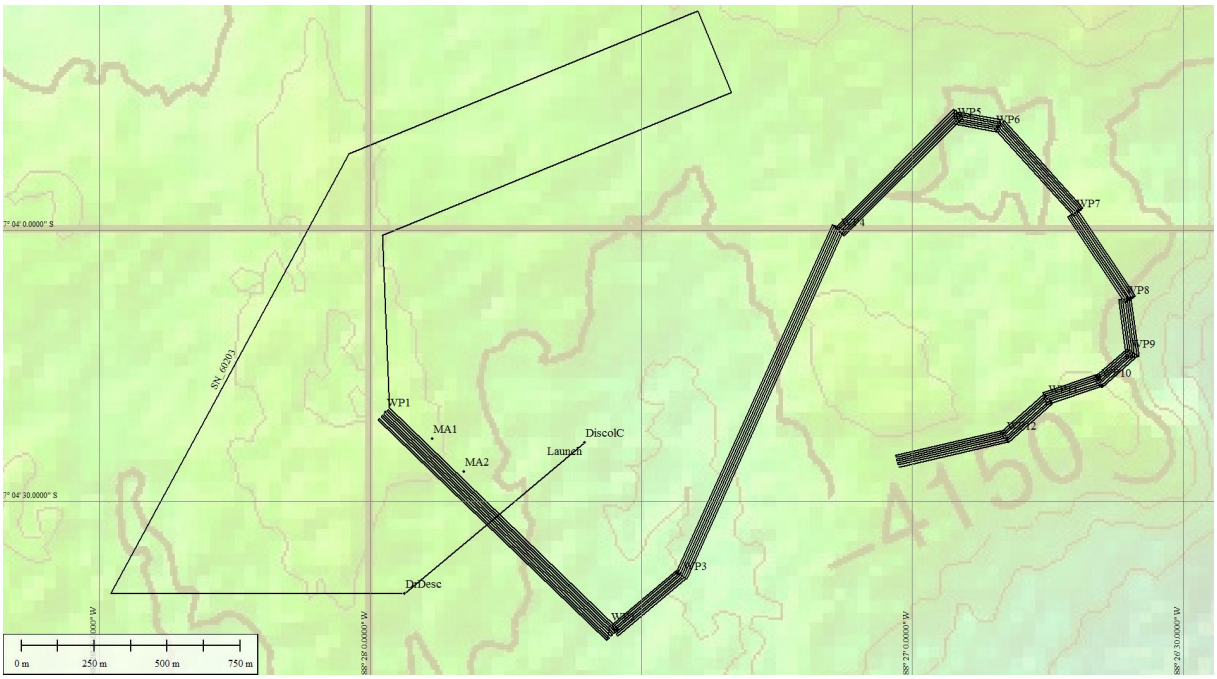


Figure 8.1.1.18: Dive plan of mission 197.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	7.0 m	Line spacing:	7 m

Total amount images:	37.000
Designation of good images:	SO242-1_088_AUV11 Identifier 1237-35487

The vehicle dived during the survey in depths between 4090 and 4145 meters.

Station 242-1_94-1 / Dive Abyss0198 / Area DEA

Date:	15th August 2015	Launch: 20:55 UTC	Recovery: 14:31 UTC
Survey time:	11.42 hours	Distance travelled: 75.3 km	
Sensors:	Edgetech Sidescan Sonar 120 kHz, Electronic Still Camera (Canon 6D)		

Mission 198 was supposed to explore the uncovered parts of the DEA and to get a larger overview of seafloor. The two sidescan survey patterns are to see the EBS track in relation to BOBO and DOS lander and to map the southern plough tracks. The vehicle dived in camera configuration and it flew during all of the survey in depths between 4085 and 4155 meters. The zigzag photo survey through the DEA area was chosen to cover as much as possible seafloor. The camera and vehicle settings are shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	6.0 m	Line spacing:	-

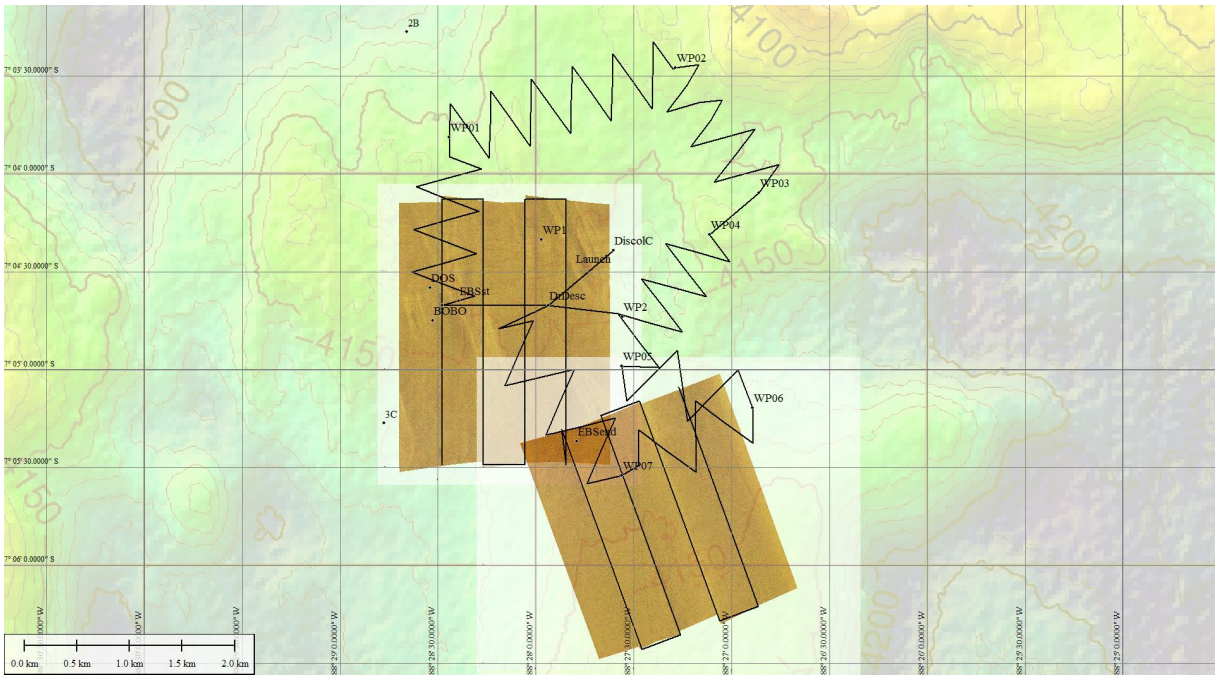


Figure 8.1.1.19: Dive plan of mission 198.

Total amount images:	30,000
Designation of good images:	SO242-1_094_AUV12 Identifier 0-23782

Both sidescan survey pattern were done by using the same settings as shown in the box below.

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	390 m
Total amount of SSS raw files:	32				
Designation of used SSS raw files:	DATA0000000 - DATA0000031				

The vehicle covered during both surveys an area of 4.39 / 4.26 km^2. This corresponds with an average coverage of 2.29/2.22 km^2/hour according the settings.

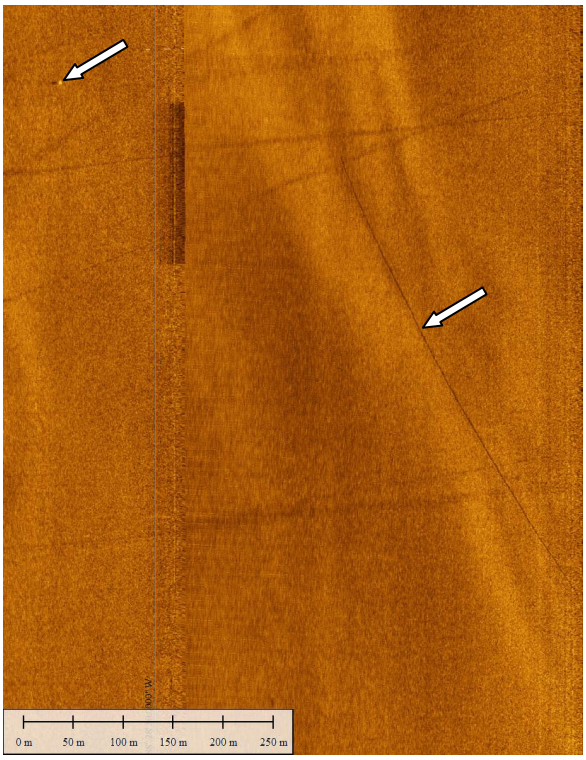


Figure 8.1.1.20: Cut-out of the sidescan map with DOS lander and EBS track.

Station 242-1_102-1 / Dive Abyss0199 / Area DEA

Date:	16th August 2015	Launch: 23:07 UTC	Recovery: 14:52 UTC
Survey time:	9.28 hours	Distance travelled: 64.4 km	
Sensors:	Electronic Still Camera (Canon 6D)		

Mission 199 was supposed to do a photo survey with less altitude above the central DEA area where the OFOS passed and "higher" photo mosaic already exists. Additionally a photo survey pattern with larger line spacing should be done above the long southern plough tracks.
The vehicle dived in camera configuration and covered in the central survey an area of 0.11 km^2 during the photo survey. This corresponds with an average coverage of 0.018 km^2/hour according the settings shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	4.5 m	Line spacing:	4.0 m

The camera and vehicle settings are shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	6.0 m	Line spacing:	100.0 m

Total amount images:	40,000
Designation of good images:	SO242-1_102_AUV13 Identifier 12538-33328

The vehicle dived during the both surveys in depths between 4120 and 4150 meters.

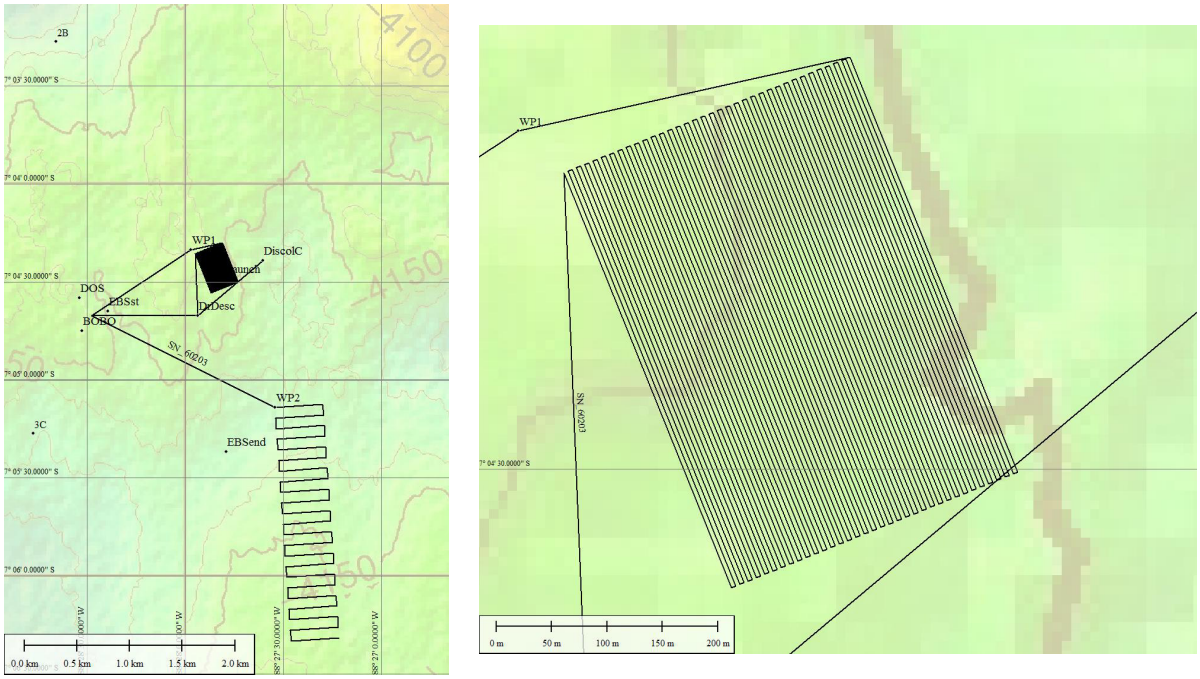


Figure 8.1.1.21: Dive plan of mission 199

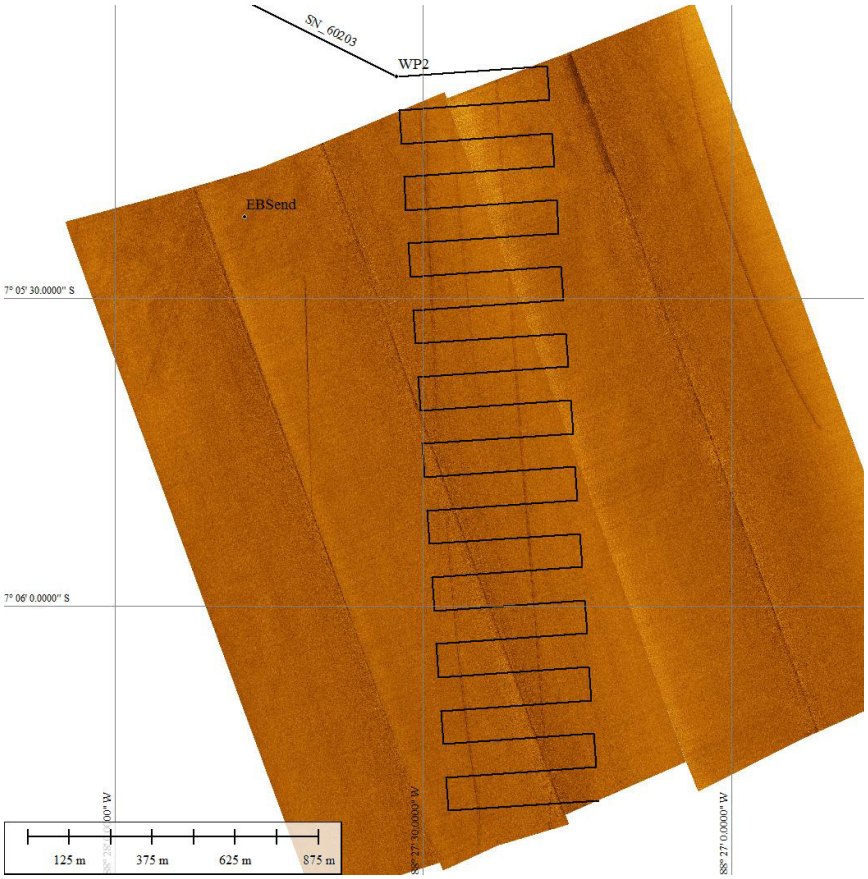


Figure 8.1.1.22: Photo zigzag above the southern plough marks (dive 199; map done during dive 198).

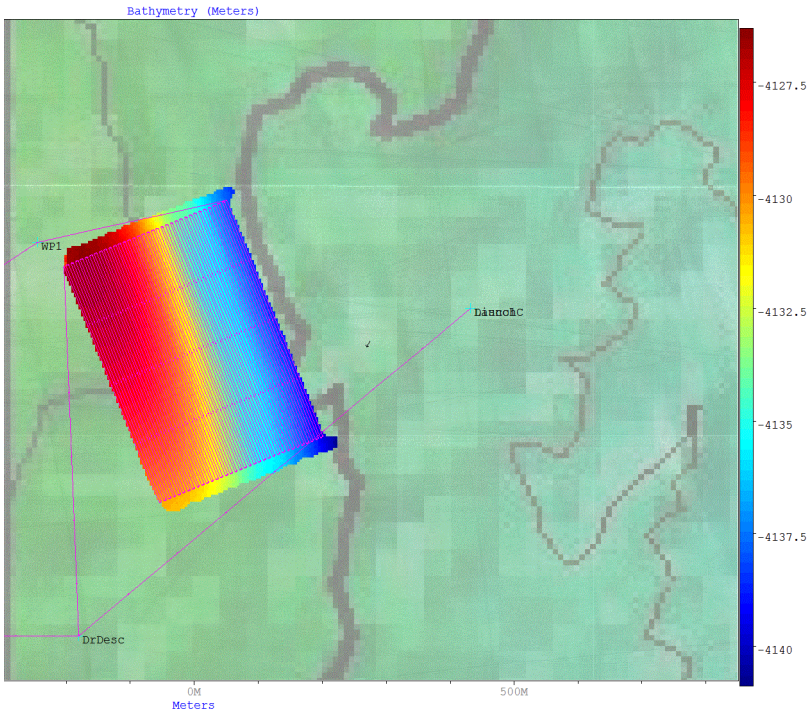


Figure 8.1.1.23: "Singlebeam" map of the central survey pattern (dive 199).

Station 242-1_107-1 / Dive Abyss0200 / Northwest off DEA

Date:	17th August 2015	Launch: 21:32 UTC	Recovery: 10:01 UTC
Survey time:	6.77 hours	Distance travelled: 54.8 km	
Sensors:	Electronic Still Camera (Canon 6D)		

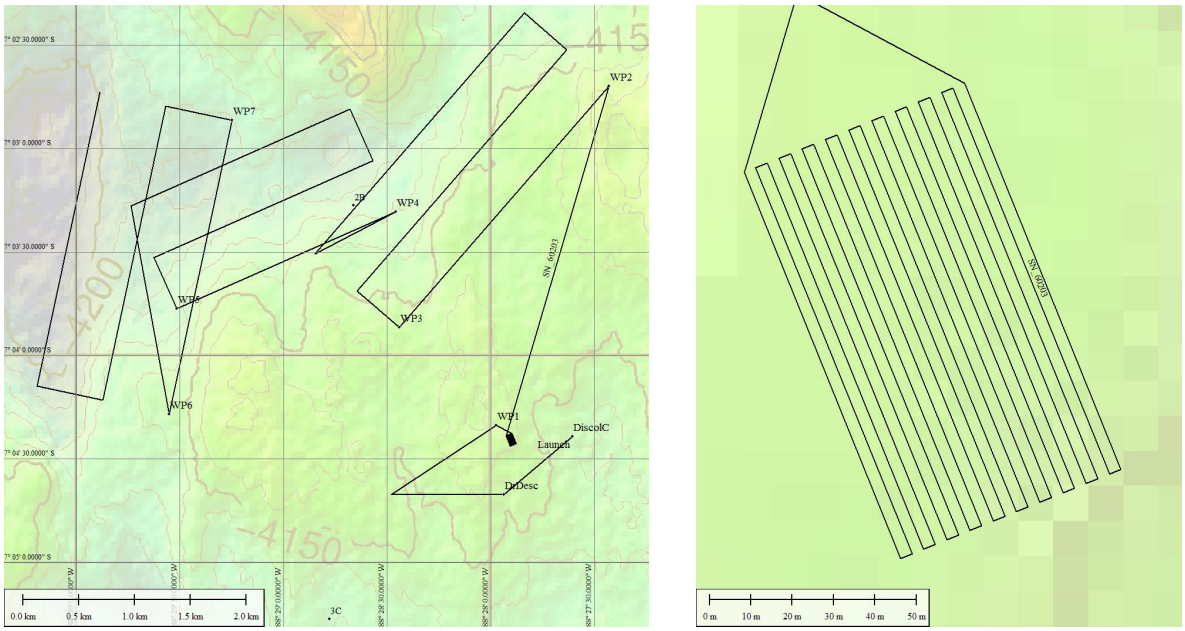


Figure 8.1.1.24: Dive plan of mission 200

Mission 200 was supposed to explore the area north and northwest off the DEA. The mission started again with a small photo survey with less altitude above the central DEA area where the OFOS passed and "higher" photo mosaics already exist. The vehicle dived in camera configuration and covered in the central survey an area of 0.0057 km^2 during the photo survey. This corresponds with an average coverage of 0.004 km^2/hour according the settings shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	4.0 m	Line spacing:	3.0 m

Three large pattern were chosen to explore the northern areas. The camera and vehicle settings are shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	7.0 m	Line spacing:	500 m

Total amount images:	28,500
Designation of good images:	SO242-1_107_AUV14 Identifier 2400-27340

The vehicle dived during the both surveys in depths between 4110 and 4200 meters.

Station 242-1_113-1 / Dive Abyss0201 / Southern reference area

Date:	19th August 2015	Launch: 02:16 UTC	Recovery: 16:40 UTC
Survey time:	9.72 hours	Distance travelled: 65.7 km	
Sensors:	Electronic Still Camera (Canon 6D)		

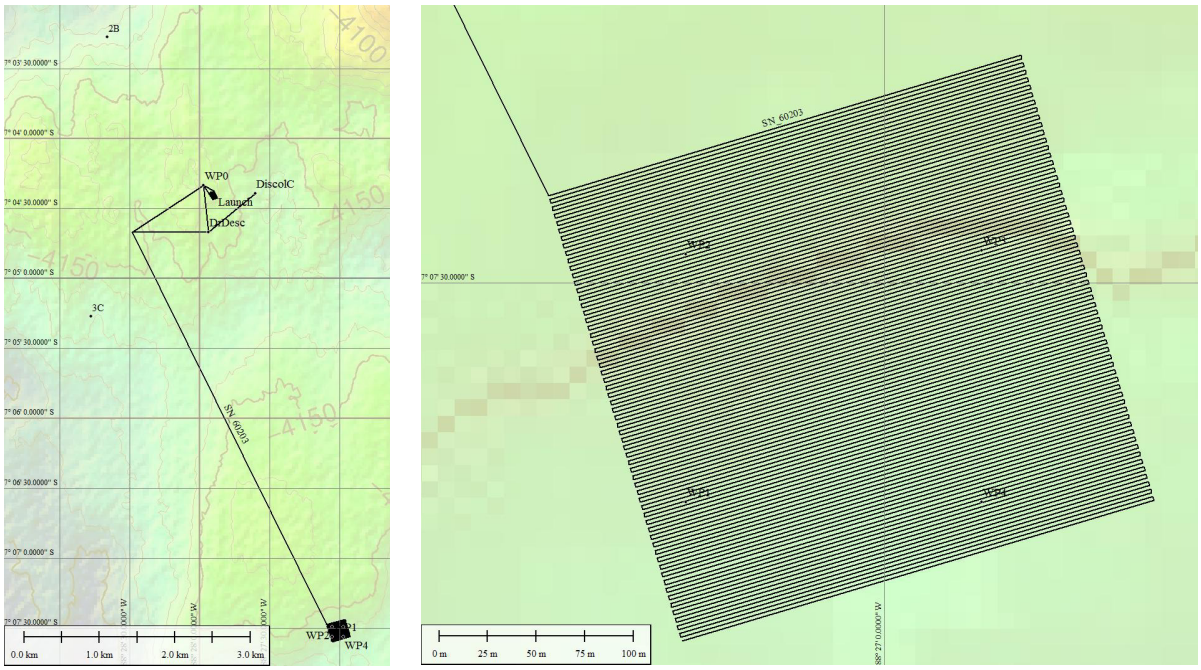


Figure 8.1.1.25: Dive plan of mission 201.

Mission 201 was supposed to do a second photo mosaic with less altitude above the southern reference area. The mission started again with a small photo survey with above the central DEA area. This time only raw picture were logged.
The vehicle dived in camera configuration and covered in the central survey an area of 0.006 km^2 during the photo survey. This corresponds with an average coverage of 0.0074 km^2/hour according the settings shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	4.0 m	Line spacing:	2.5 m

The main pattern in the southern reference had an area of 0.06 km^2 that means a average coverage of 0.0081 km^2/hour according the settings shown in the box below.

Aperture:	5.6	Exposure time:	1/160	Sample rate:	1.0 Hz
Vehicle speed:	3.0 knots	Altitude:	4.5 m	Line spacing:	2.0 m

Total amount images:	19,000
Designation of good images:	SO242-1_113_AUV15 Identifier 860-18750

The vehicle dived during the both surveys in depths between 4121 and 4152 meters.

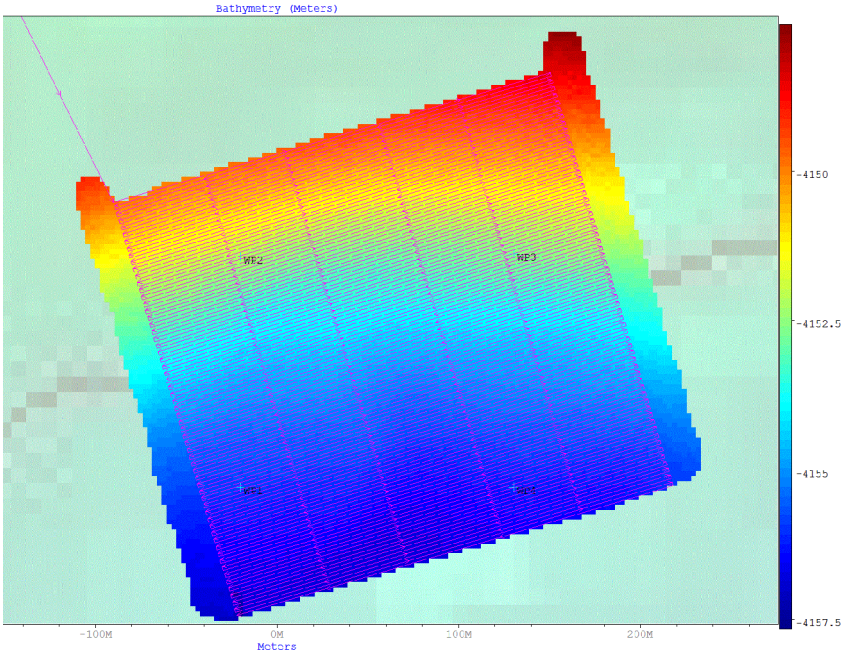


Figure 8.1.1.26: "Singlebeam" map of the southern reference area.

Station 242-1_118-1 / Dive Abyss0202 / Northeast off DEA

Date:	20th August 2015	Launch: 05:54 UTC	Recovery: 01:56 UTC
Survey time:	13.27 hours	Distance travelled: 91.8 km	
Sensors:	Edgetech Sidescan Sonar 120 kHz, Edgetech Sub-Bottom Profiler (Test settings)		

Mission 202 was supposed to extent the sidescan map in a northeastward direction to the 'hilly' area. The dive was done in sub-bottom profiler configuration. Two test tracked were chosen to test the usable SBP settings. The vehicle flew in bottom following mode. Despite different mission planning the SBP was logging from the beginning. The box below shows the settings for the SBP tests.

SBP frequency:	4-16 kHz 10FM / 4-20 kHz 20FM / 4-20 kHz 10WB / 4-20 kHz 20FM / 4-24 kHz 10FM / 4-24 kHz 5FM				
Range:	75 / 100 m				
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	-
Total amount of SBP raw files:	53				
Designation of used SBP raw files:	DATA0000262-DATA0000274, DATA0000277-DATA0000284				

The vehicle headed northward after finishing the SBP tests and mapped the area northeast of the DEA by using sidescan (see settings in the box below). The vehicle dived during the sidescan survey in depth between 4010 and 4110 meters and covered an area of 12.26 km^2. That means 1.9 km^2/hour on average .

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	300 m
Total amount of SSS raw files:	51				
Designation of used SSS raw files:	DATA0000000 - DATA0000050				

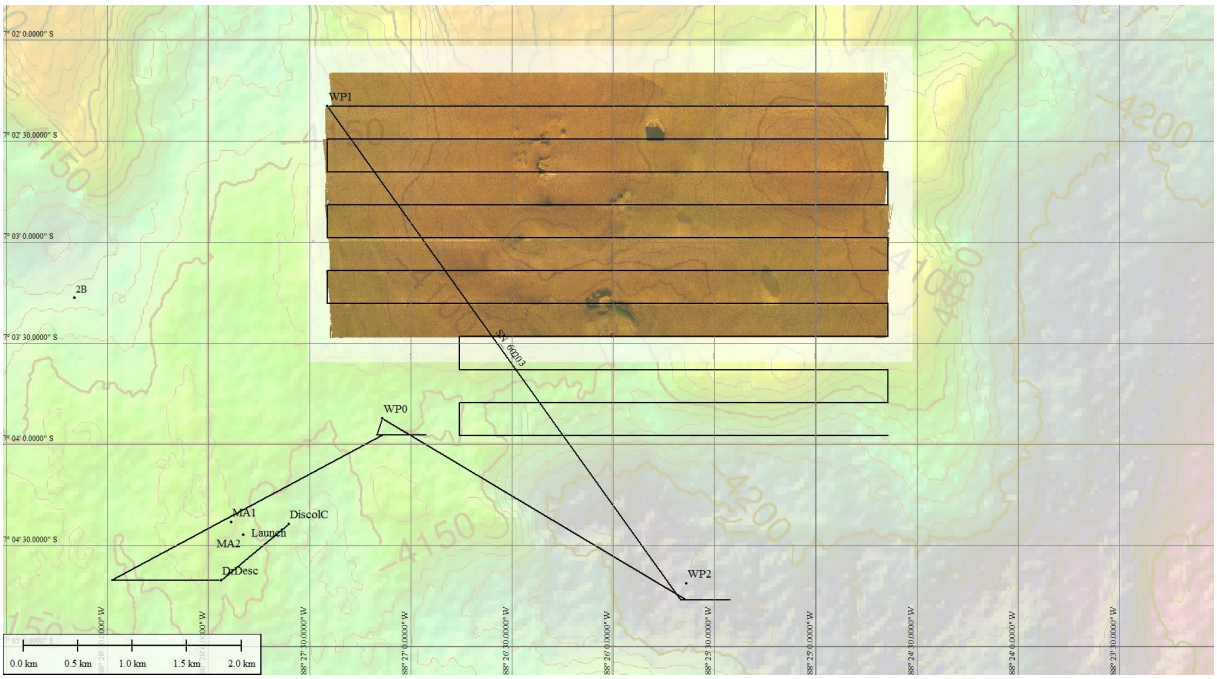


Figure 8.1.1.27: Dive plan of mission 202.

The vehicle could not finish the planned sidescan survey due to less battery power. It headed to the ascent position after reaching 5% battery power and aborted the mission there. Just some minutes later a reset of the vehicle computer happened and the logfile stopped abruptly.

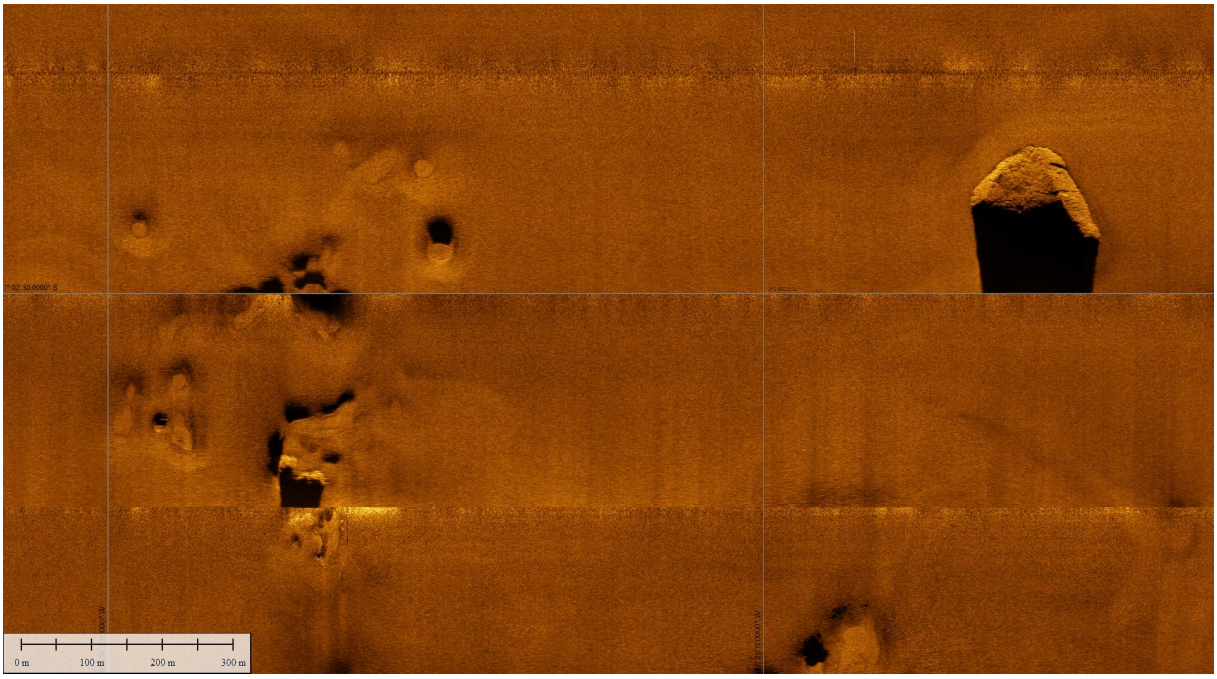


Figure 8.1.1.28: Basalt structure northeast off the DEA.

Station 242-1_125-1 / Dive Abyss0203 / East off DEA

Date:	21st August 2015	Launch: 09:51 UTC	Recovery: 02:28 UTC
Survey time:	10.32 hours	Distance travelled: 74.9 km	
Sensors:	Edgetech Sidescan Sonar 120 kHz,		
	Edgetech Sub-Bottom Profiler (SBP) (Test settings, Profiling)		

Mission 203 was supposed to finish the sidescan mapping northeast off the DEA area of dive 202 and do the first sub-bottom profiling. The dive was done in sub-bottom configuration. Two profiling areas were planned, the northern region of the DEA and a deeper area southeast off the DEA, to get more details about the sedimentation differences seen in the ships sub-bottom profiler data.
The initial SBP test is a rerun of the test above the no nodule area ("heart") inside the DEA done in dive 202.

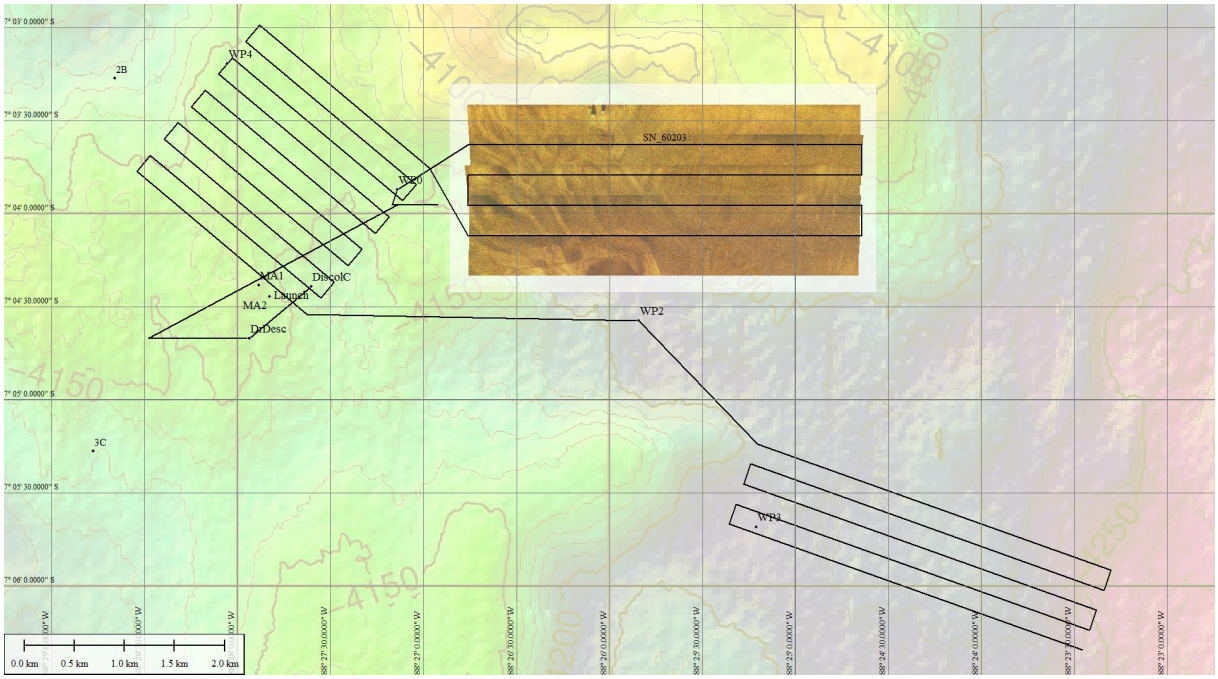


Figure 8.1.1.29: Dive plan of mission 203.

SBP frequency:	4-16 kHz 10FM / 4-20 kHz 20FM / 4-20 kHz 10WB / 4-20 kHz 20FM / 4-24 kHz 10FM / 4-24 kHz 5FM			
Range:	100 m			
Vehicle speed:	3.0 knots	Depth: 4100 m	Altitude:	41-50 m

This time the vehicle flew on a constant depth instead of bottom following to improve the sediment profiling data. Details can be found in the box above.
The vehicle dived during the sidescan survey in depth between 4050 and 4150 meters and covered an area of 6.65 km^2. That means 2.2 km^2/hour with settings as shown in the box below.

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	300 m
Total amount of SSS raw files:	20				
Designation of used SSS raw files:	DATA0000055 - DATA0000074				

The vehicle was flown on constant depth while the planned SBP survey pattern. Despite different mission planning the SBP was logging from the beginning. It hasn't reacted to the logging on/off command in a proper way. The vehicle could not communicate with the SBP at 18:38 UTC (NW survey pattern) and stopped logging until mission end. All file which were generated after this time are defective.

SBP frequency:	4-16 kHz 10FM			
Range:	100 m		Vehicle speed:	3.0 knots
Depth: 4100	Altitude:	22-50 m	Line spacing:	210 m

Total amount of SBP raw files:	51	
Designation of used raw files (Test):		DATA0000366-DATA0000372,
Designation of used raw files (Survey NW):		DATA0000391- DATA0000402 (not finished)
Designation of used raw files (Survey SE):		no files logged

The SBP jsf files are not processed yet. During the southeast survey pattern the vehicle stopped the survey due to battery power and headed straight to the endpoint to abort the mission. Just before the endpoint a reset happened and the log file was stopped abruptly. The reason for this reset is not figured out yet.

8.1.2 Ship and AUV-based multibeam mapping

Evangelos Alevizos, Anja Steinführer & Anne Peukert

Transit Guayaquil - DISCOL

During SO242/1 we had to transit twice to and from Guayaquil. As a result we collected an extensive bathymetric data set using the MBES system of the vessel (Figure 7.1.2). Data were collected only outside the EEZ of Ecuador. Preliminary investigations of these data reveal numerous seamounts as the result of past volcanic activity at depths between 2500-4200 meters. Other tectonic features such as a pull-apart basin in the central part of the mapped area illustrate the complex morphology and tectonic history of this area. North-south striking graben and horst structures show the extension of the crust in W-E direction.

Table 8.1.2.1: Areas and data files recorded.

Area / Survey	.all file numbers
Larger DISCOL area	0018 – 0023, 0048 – 0050, 0054 - 0056
Transit 1 (Mid North)	0000 - 0009
Transit 2 (Mid South)	0026 - 0035
Transit 3 (North)	0037 - 0047
Transit 4 (South)	0058 - 0068

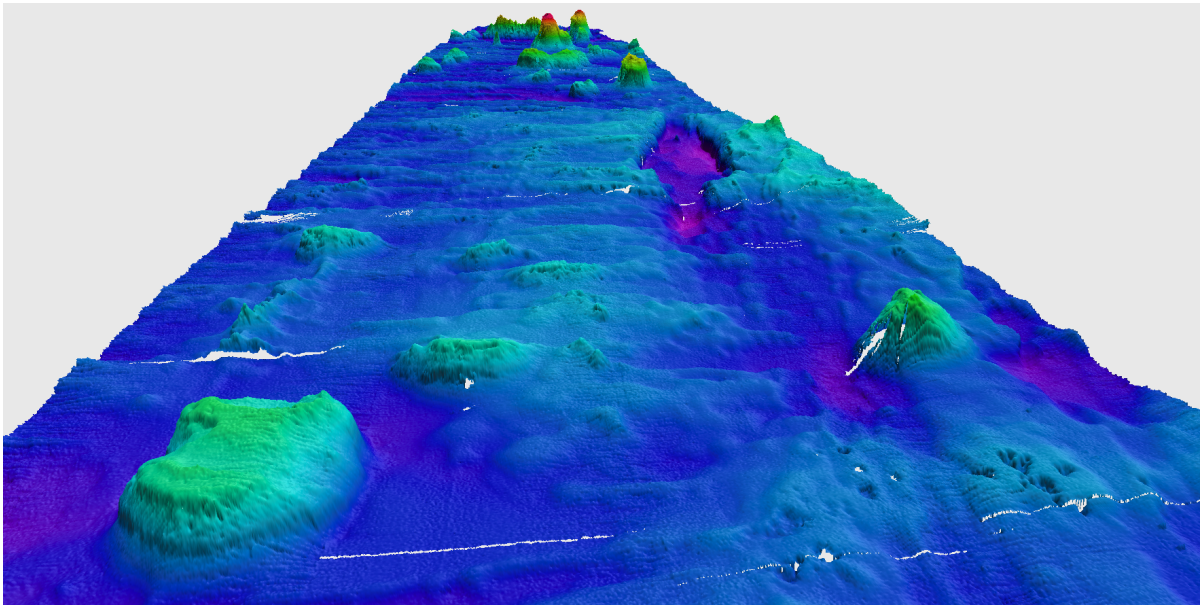


Figure 8.1.2.1: View from the NE towards the DISCOL area.

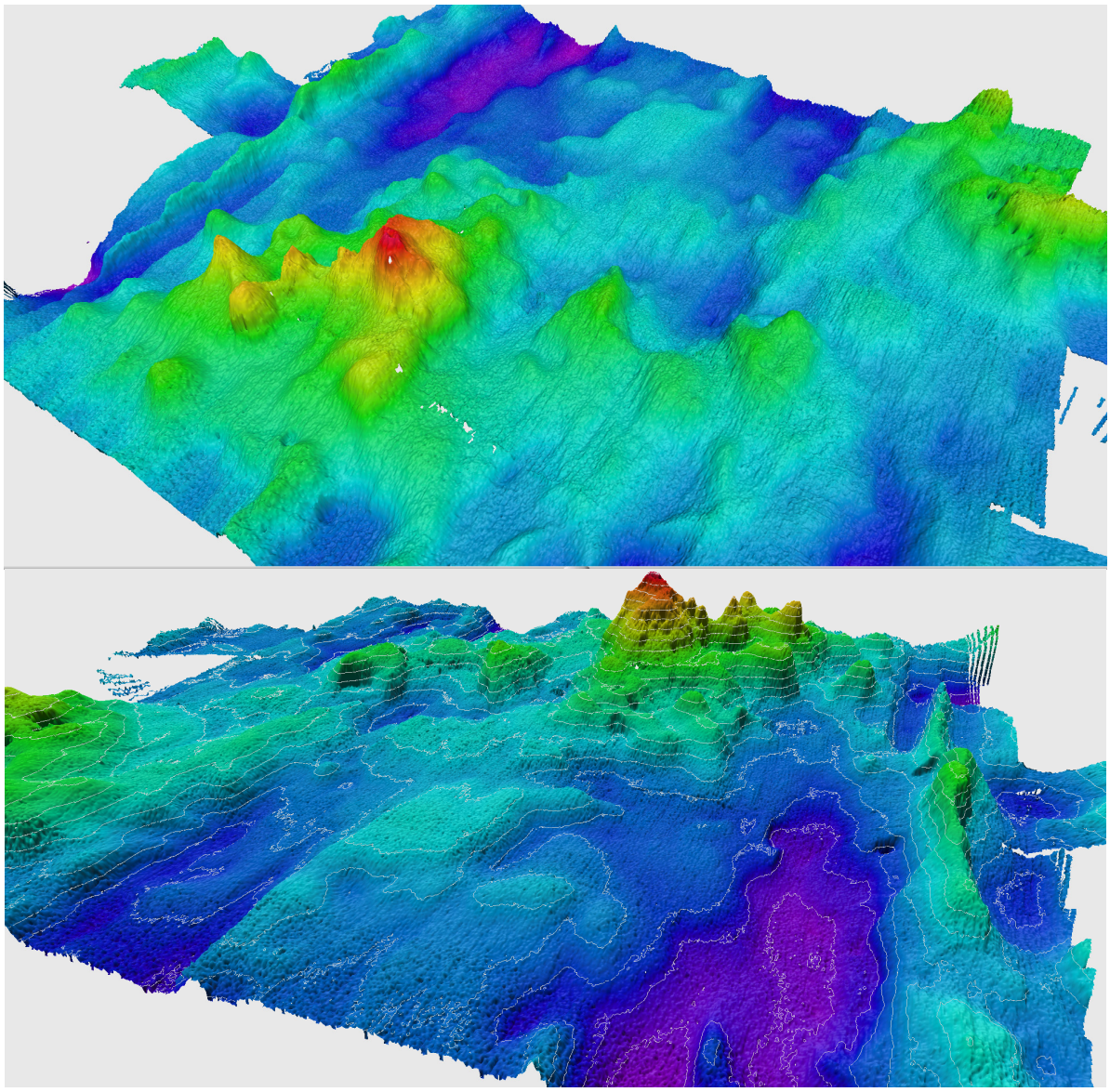


Figure 8.1.2.2: View towards the DISCOL area from NW (top) and SE (bottom) light grey contours are every 25m)

DISCOL Area EM122

One bathymetric survey was performed in the DISCOL area and additional data were acquired when deploying Amphi-Trap-5 (SO242/1_#106) towards the NW of the DEA (Table 8.1.2.2). The bathymetry is shown in Figure 8.1.2.2 using a 30 meters cell size. Detail description of the sonar system used can be found in chapter 7.1. The sonar files (.ALL) were imported and edited using DMagic module of the Fledermaus software. The edited bathymetric data points were exported as xyz ascii file and imported to SAGA-GIS and ArcGIS for interpolation and further analysis. By applying geospatial surface analysis we calculated two bathymetric derivatives the slope and the broad scale Bathymetric Position Index (BPI). The slope was calculated in degrees after the surface was transformed to UTM coordinates. The slope is the first derivative of the bathymetric surface and is a measure of how steep the bathymetry changes at places. The BPI is a measure of the relative elevation of bathymetric features compared to their neighborhood. For this calculation we set an inner radius of 900m and outer radius of 6000m taking into account the bin size of the bathymetry and the area covered by the survey. This BPI settings resulted highlight the broad scale bathymetric

features of the area such as the seamounts in the NE and SW, the N-S striking depressions (graben structures) that bound the DEA area and the tectonic ridge to the east.

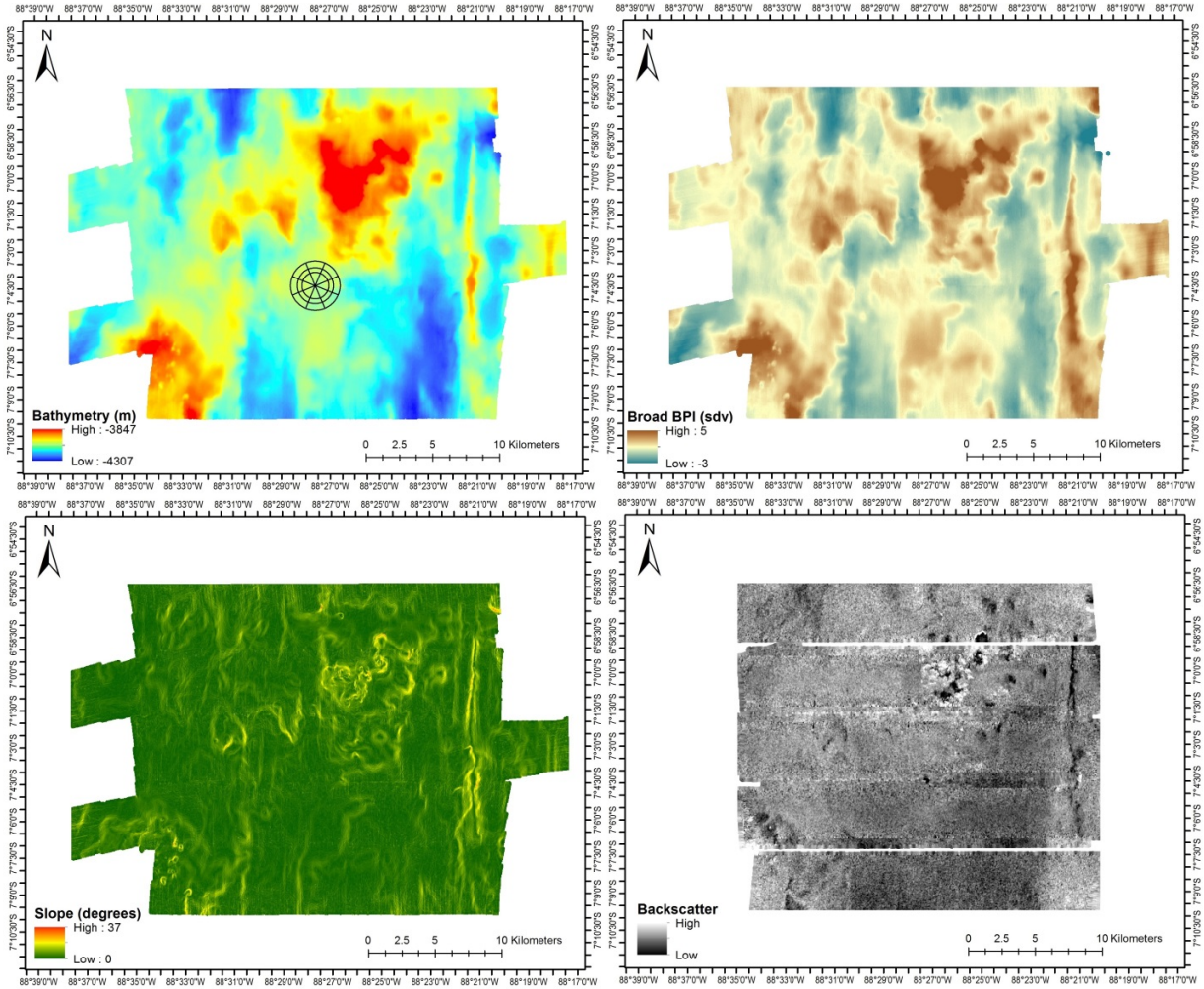


Figure 8.1.2.2: Upper left, bathymetry of the wider area of DISCOL from the ship-based MBES with the DEA area shown as black circle. Upper right, broad scale Bathymetric Position Index (BPI) showing the relative elevations/depressions in the area. The BPI is measured in number of standard deviation. Lower left, is the slope of bathymetric surface and lower right is the backscatter intensities from the ships MBES.

Apart from the bathymetric analyses we extracted the backscatter mosaic of the area using the FMGT Geocoder module of the Fledermaus software. This module requires that first we import the bathymetric edits in order to calculate the backscatter values. The FMGT Geocoder applies geometric and radiometric corrections to the data and outputs a map with average backscatter intensity for each pixel. The geometric corrections account for compensation due to the bathymetry and slope which affect the backscatter intensity whereas the radiometric corrections account for the sonar settings such as gain, transmit power and absorption. The corrected backscatter mosaic was exported as xyz ascii file and then imported in SAGA-GIS for interpolation using a 30 meter bin size. High backscatter values are denoted by brighter tones in the greyscale image (lower right Figure 8.1.2.2) whereas darker tones represent lower backscatter intensities. In general backscatter intensity is highly related to the sedimentary type of the seafloor meaning that high backscatter is the result of harder material whereas lower backscatter is due to softer substrate.

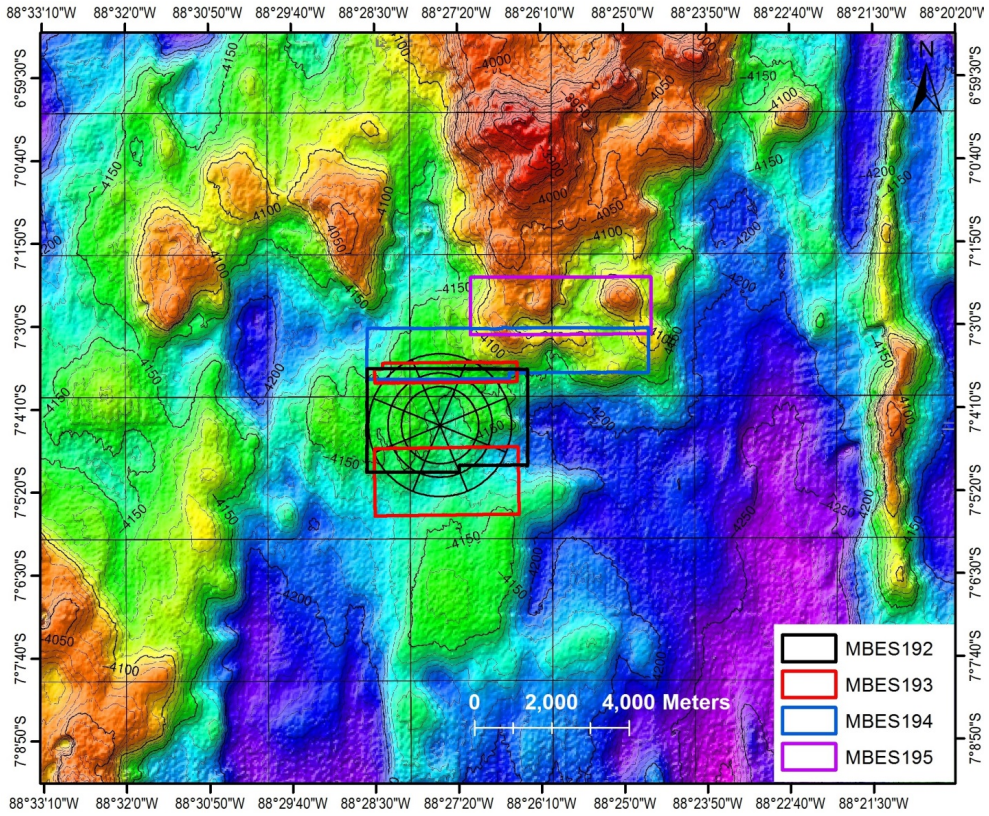


Figure 8.1.2.3: Illuminated bathymetry of the DISCOL area with the DEA circle and the areas of the different AUV bathymetric surveys. Illumination from NW, processed with GMT.

Table 8.1.2.1: AUV MBES settings

Sonar system	RESON 7125
Frequency (kHz)	200
Number of beams	256
Along track beam width (degrees)	1
Across track beam width (degrees)	2
Pulse length (µm)	55
Survey average altitude (m)	80
Sonar files format	s7k/GSF pair

DEA Area AUV-MBES

The DEA area was mapped in high resolution using the AUV MBES (Figure 8.1.2.3). Table 8.1.2.1 details the sonar settings. The data allowed producing grids with two meters cell size (Figure 4). The DEA area comprises of low and smooth relief with a 20 meter deep valley in the central part as a main morphological feature. Within this valley fine scaled N-S striking ridges appear in the AUV bathymetry showing a maximum height of one meter and a width of several tens of meters. These features show various intensities in the side scan sonar backscatter response (see below).

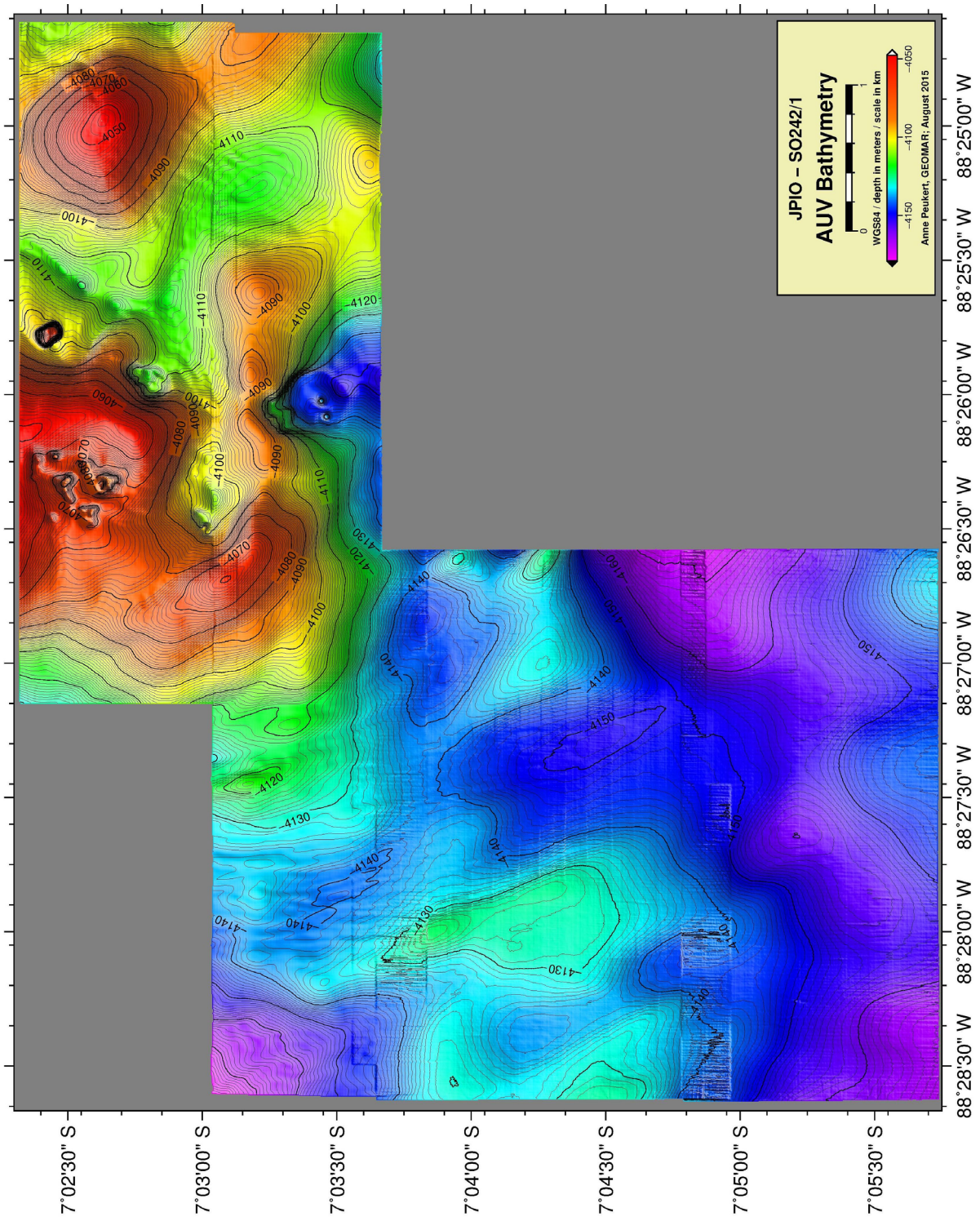


Figure 8.1.2.4: Merged AUV bathymetry data. Some artefacts still exist and need to be removed.

NW mountain area AUV-MBES

The area north of the DEA comprises of variable relief bathymetry with elevation differences up to 150 meters (Figure 5). The main bathymetric features include crater-shaped terrain with steep slopes, local depressions and both broad and fine scale seamounts. The main elevated area to the west and the circular large scale seamount to the east are separated by a smooth slope valley with deep central part. The deeper part towards the west of the area includes the northern extend of the seafloor undulations detected in the DEA area.

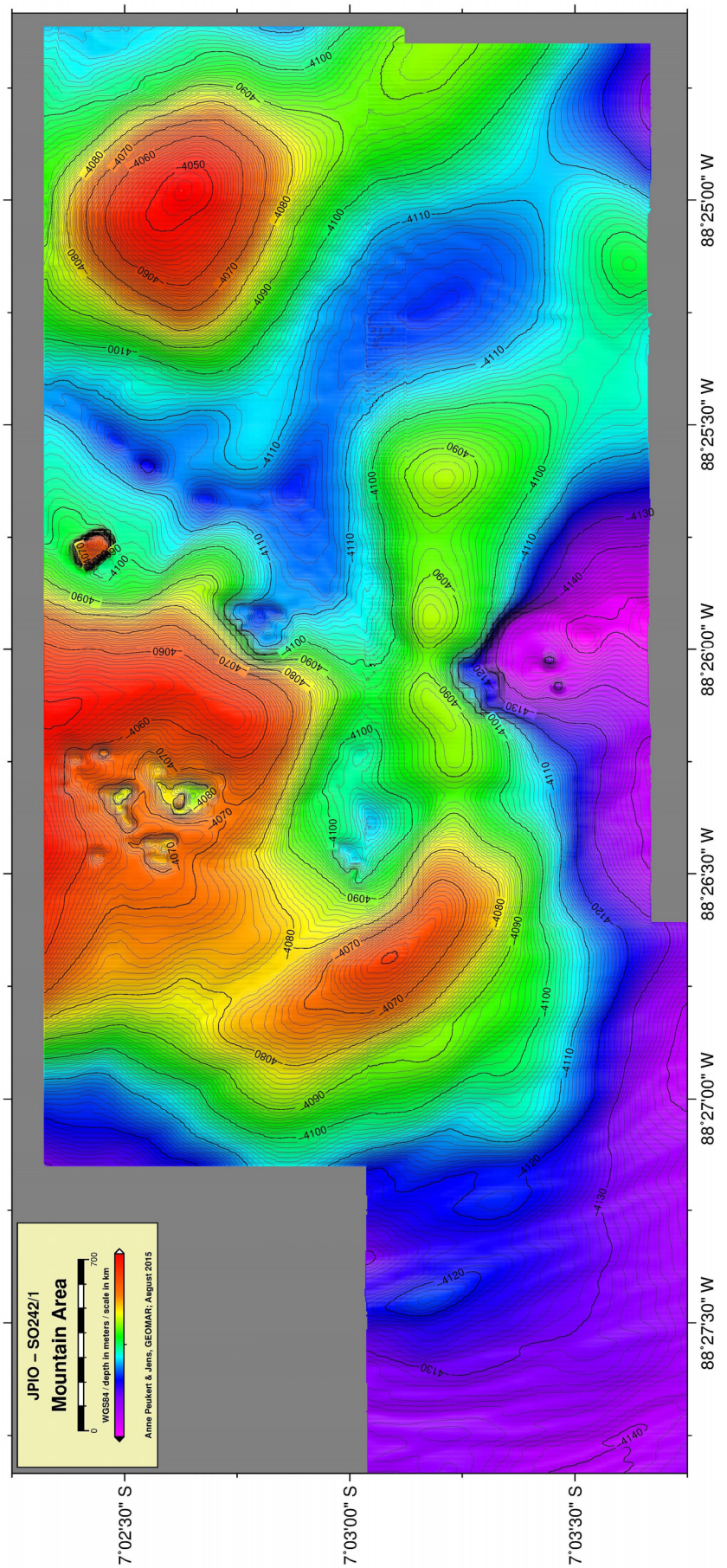


Figure 8.1.2.5: Mountain area NE of the DEA.

8.1.3 AUV-based sidescan mapping

Evangelos Alevizos, Anja Steinführer & Jens Greinert

High resolution seafloor acoustic imagery from the AUV sidescan sonar provided detailed information regarding the different seafloor textures of the DEA area and the adjacent mountain area. Figure 8.1.3.1 shows the areas surveyed by the side scan sonar. Some areas have been scanned with high and low frequency and from different altitudes (see chapter 8.1.1).

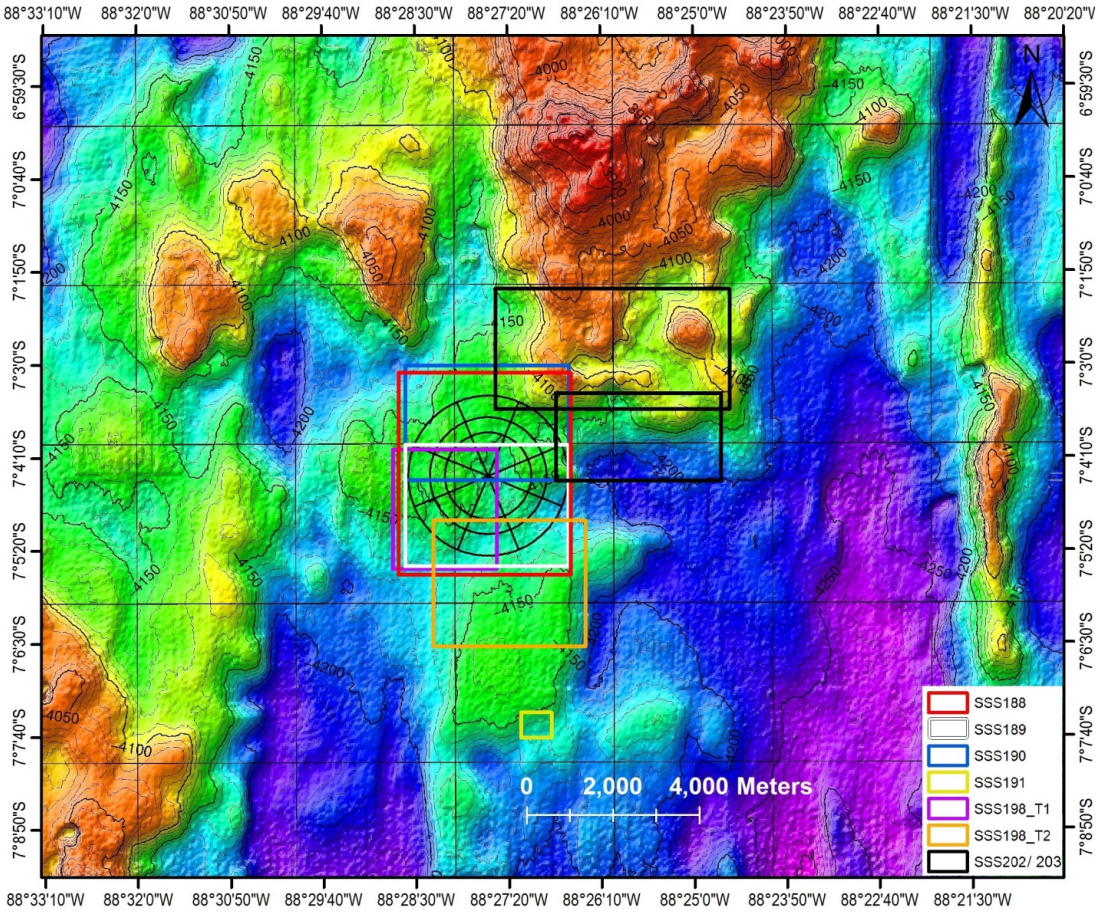


Figure 8.1.3.1: Compilation of the different AUV sidescan surveys.

DEA area

The bathymetric features identified from the AUV bathymetry appear to have also discrete expression in the side scan sonar mosaic. The most prominent features include a) the plough marks which appear as thin dark lines (Figure 8.1.3.2), b) areas of low reflectivity and c) alternations of high and low reflectivity as a result of the ensonification angle of the side scan sonar compared to the small scale valley and ridge pattern on the seafloor. The areas of low reflectivity comprise nodule-free areas according to OFOS observations and include the heart-shaped area and the circular area in the NE part the sidescan data (Figure 8.1.3.2) and the elongated area SE of central part of the DEA. These areas also appear as depressions with a very flat bottom in the AUV bathymetry.

The sidescan sonar image although it was exported as georeferenced tif file needed to be manually adjusted based on the accurate locations of plough mark sequences seen in the USBL guided OFOS tracks. The plough mark positions on the side scan sonar image assisted the planning of OFOS surveys regarding the disturbance areas and helped selecting appropriate locations for multicorer and box corer sampling. From the side scan sonar image it is possible to identify most of the plough marks created in 1989 which makes it makes it possible to digitization their exact

position. All obvious plough marks were digitized as lines in ArcGIS from the side scan sonar image. It is also possible to identify the very first plough marks which were held using a 16 meter wide plough. Moreover it is possible to identify “younger” plough marks due to their more pronounce appearance in contrast to the more fainted signals of the older ones. It should be mentioned that the accurately georeferenced sidescan sonar image can provide a mean to validate the position of older OFOS tracks based on feature correspondences (like plough marks).

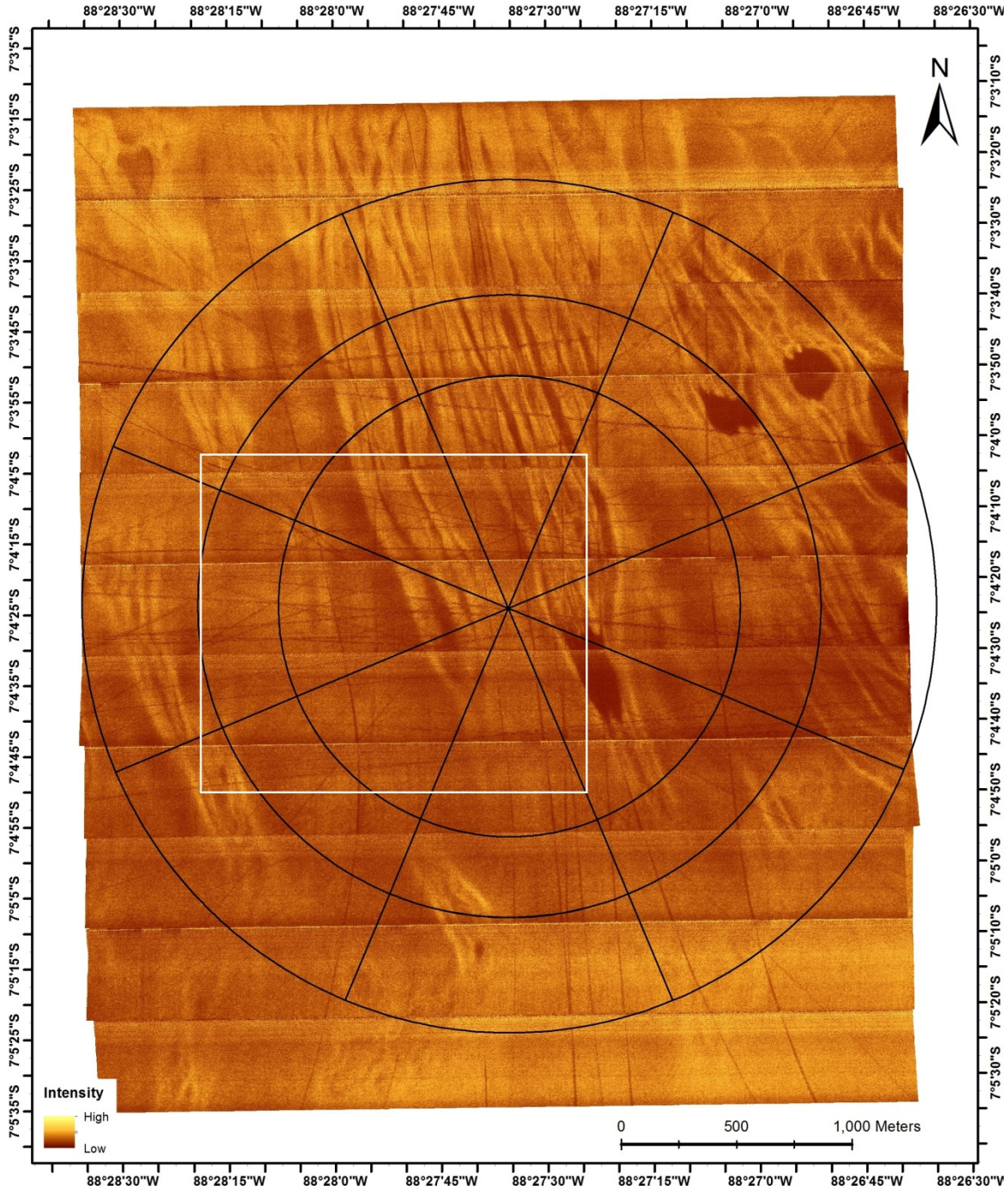


Figure 8.1.3.2: Sidescan sonar imagery of AUV-dive 188 of the DEA area also showing the DEA circle. The thin dark lines are the plough marks of the disturbance experiment. The white rectangle indicates the boundaries of a close-up where the central and most impacted area is highlighted in Figure 8.1.3.3.

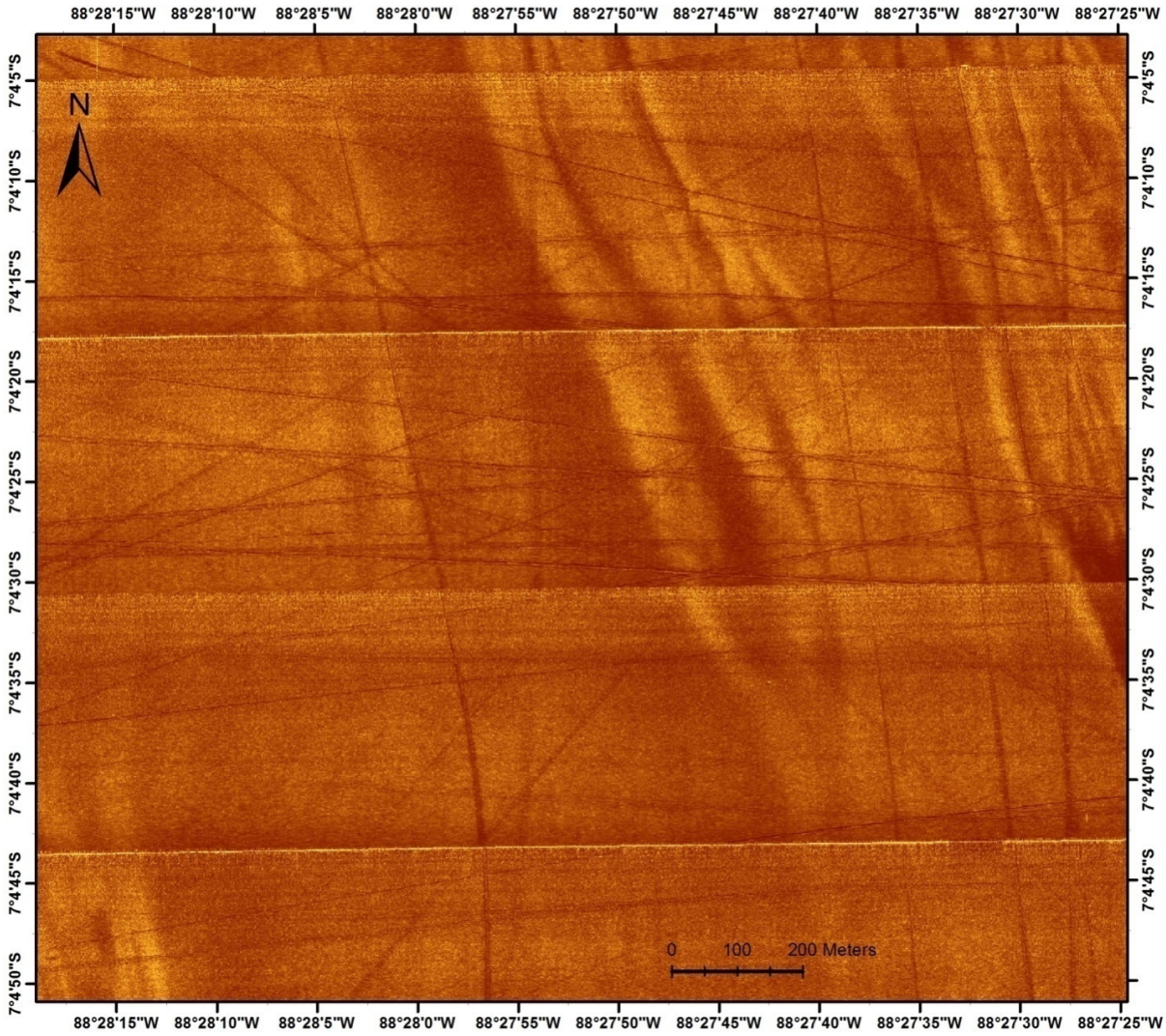


Figure 8.1.3.3: Close-up of the central part of the DEA.

Northwest of the DEA, Mountain Area

The part northwest of the DEA area includes two sidescan sonar surveys (AUV-202, -203; SO242/1_#118 and SO242/1_#125) that were selected to add information to the AUV MBES dataset. The northern part of this area (Figure 8.1.3.4) includes changes in reflectivity caused by steep slopes of craters and small mountain features. Outcropping pillow basalt are seen as sharp pinnacles. They were identified as pillow basalts by OFOS-6. A larger pillow mountain is highlighted in Figure 8.1.3.4. Again we detected two ellipse shaped 'black patches' of low reflectivity which do not contain nodules as verified from OFOS survey. Regarding the southern area (Figure 8.1.3.5; AUV-203), changes in reflectivity are mainly due to small scale variability of terrain in conjunction with Mn-nodules density variations. In the northern part of the image two prominent features with steep slope and up to 10 meters height can be seen. They correspond with the features at the central southern part of Figure 8.1.3.4) and comprise local structures of basaltic origin as observed during OFOS observations.

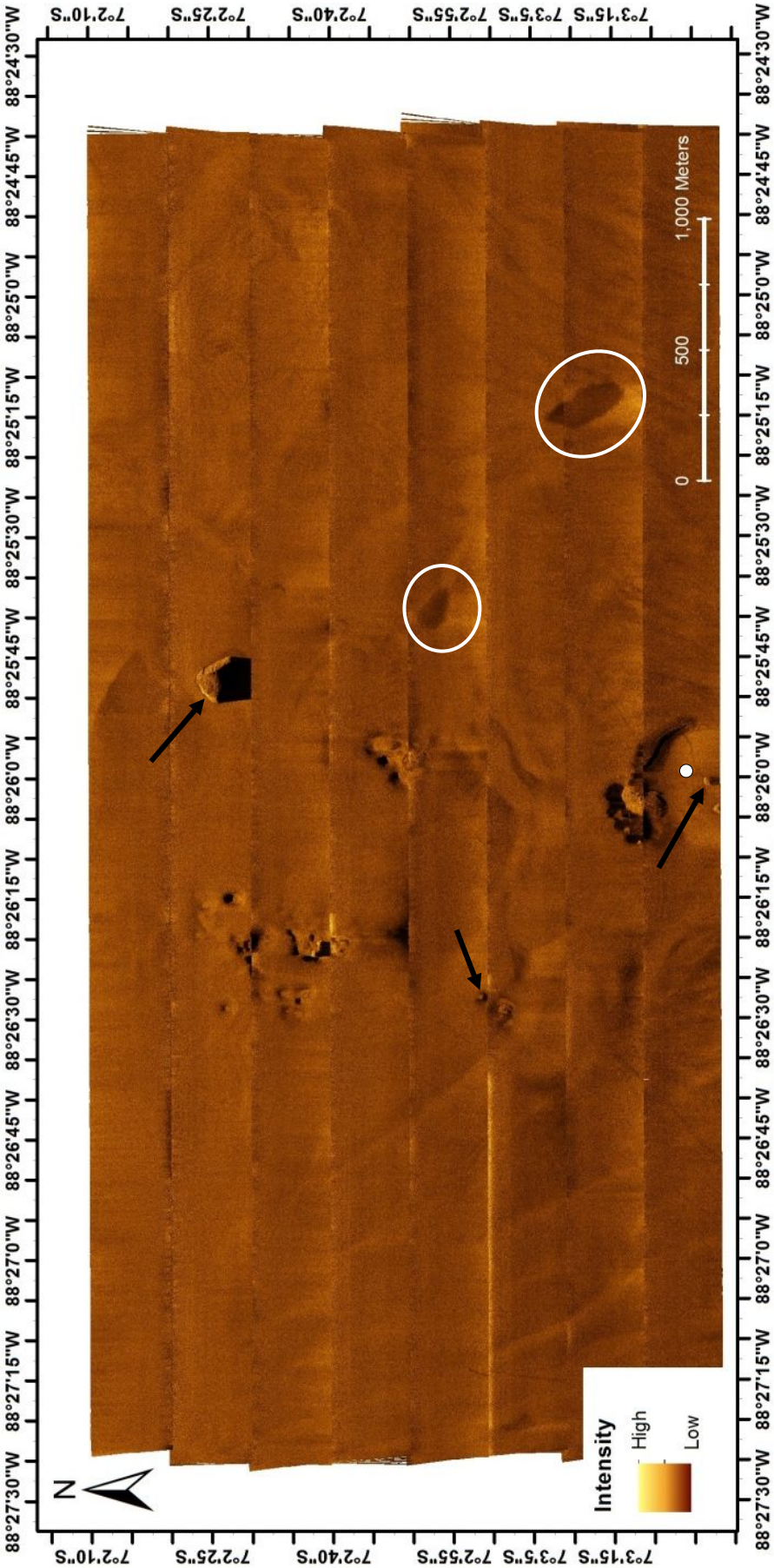


Figure 8.1.3.4: Sonar imagery from the upper part of the higher relief area. The circles indicate nodule-free areas, black arrows point to some of the pillow basalt outcrops. White dot = SO242/1_#132_GC-7.

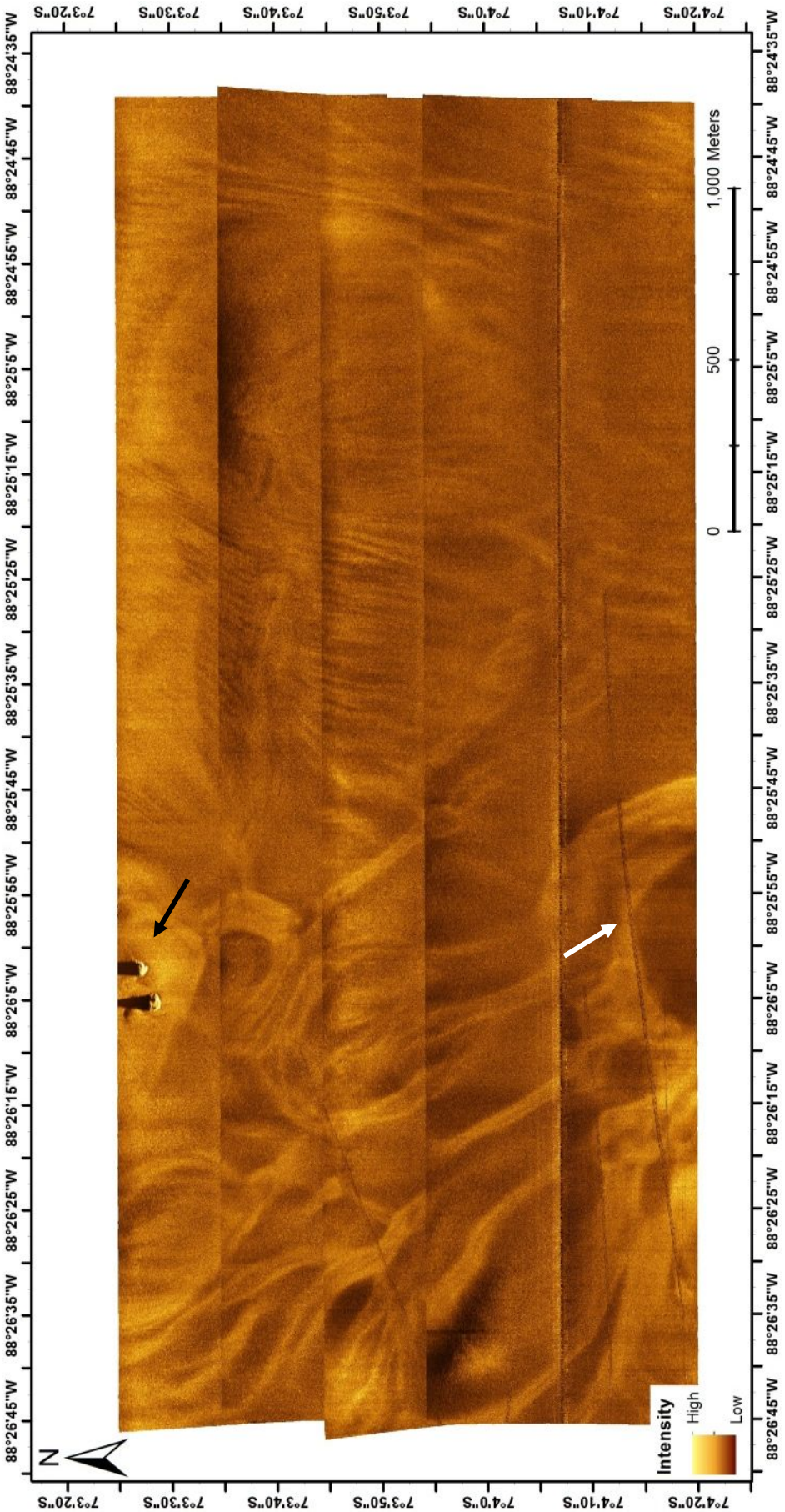


Figure 8.1.3.5: Sonar imagery from the southern part of the mountain area (AUV-203). The black arrow points to a pillow basalt mountain. The white arrow points at a plough mark.

8.1.4 AUV image management, processing and photo mosaicking

Kevin Köser, Timm Schoening & Jens Greinert

Images were acquired by several customized Canon EOS 6D onboard the AUV „Abyss“. The camera was mounted behind a dome port and a 15mm fish-eye lens was used that produces extreme wide-angle images with distortions that have to be undistorted for later analysis. „Abyss“ flew 3.5 to 8 meters (target altitudes were 4m to 7m, depending on the mission) above the seafloor. Due to the light absorption under water, the images show a mostly blue color spectrum (in particular those at higher altitude) and an illumination drop-off towards the corners and images were corrected according to the description in chapter 7.

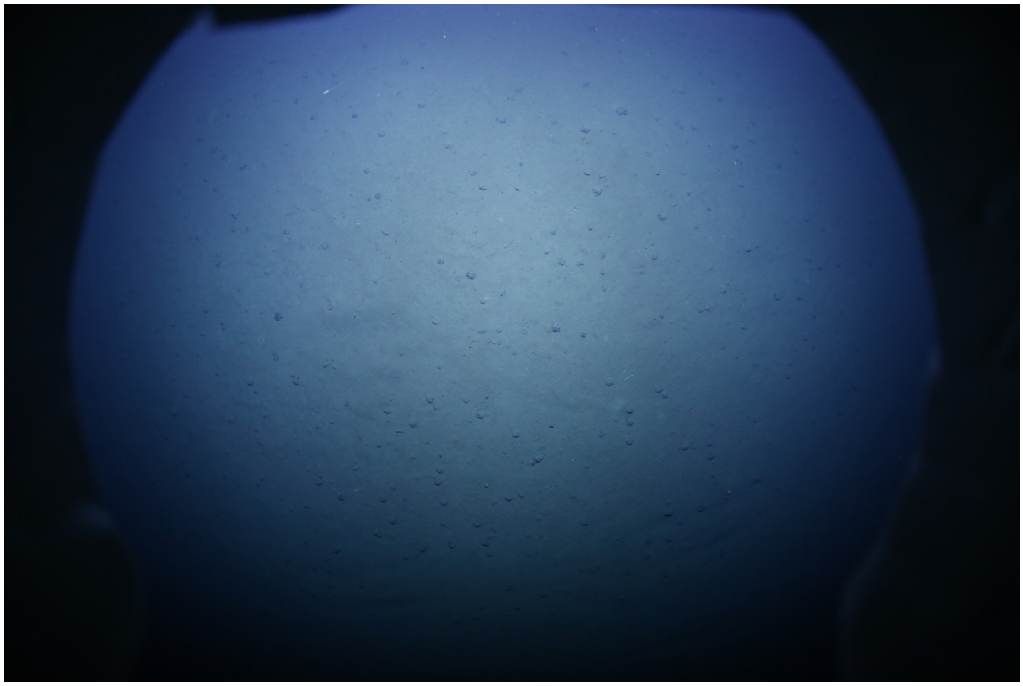


Figure 8.1.4.1: One example of a raw AUV image.

Overview of the dives

The image numbers in brackets show the amount of good images where the seafloor is clearly visible. The following maps show the position of the AUV in black and positions with successful image acquisition (i.e. images that show the seafloor clearly) are marked in white.

Dive	Images	Area	Date	Notes
SO242/1_025_AUV3	13000 (3140)	DEA	01.08.15	SSS, DOS Lander
SO242/1_033_AUV4	13000 (7450)	DEA	02.08.15	SSS, DOS Lander
SO242/1_041_AUV5	3274 (1274)	Ref. South	04.08.15	SSS, Camera broke
SO242/1_083_AUV10	37000 (34200)	DEA	13.08.15	
SO242/1_088_AUV11	37000 (34250)	DEA	14.08.15	OFOS Revisited
SO242/1_094_AUV12	30000 (23782)	DEA	15.8.	SSS, ZigZag whole DEA
SO242/1_102_AUV13	40000 (20790)	Ref. South	16.8.	
SO242/1_107_AUV14	28500 (24940)	NW of DEA	17.8.	
SO242/1_113_AUV15	19000 (17890)	DEA + Ref. South	19.08.	
Total	**220774 (167716)**			

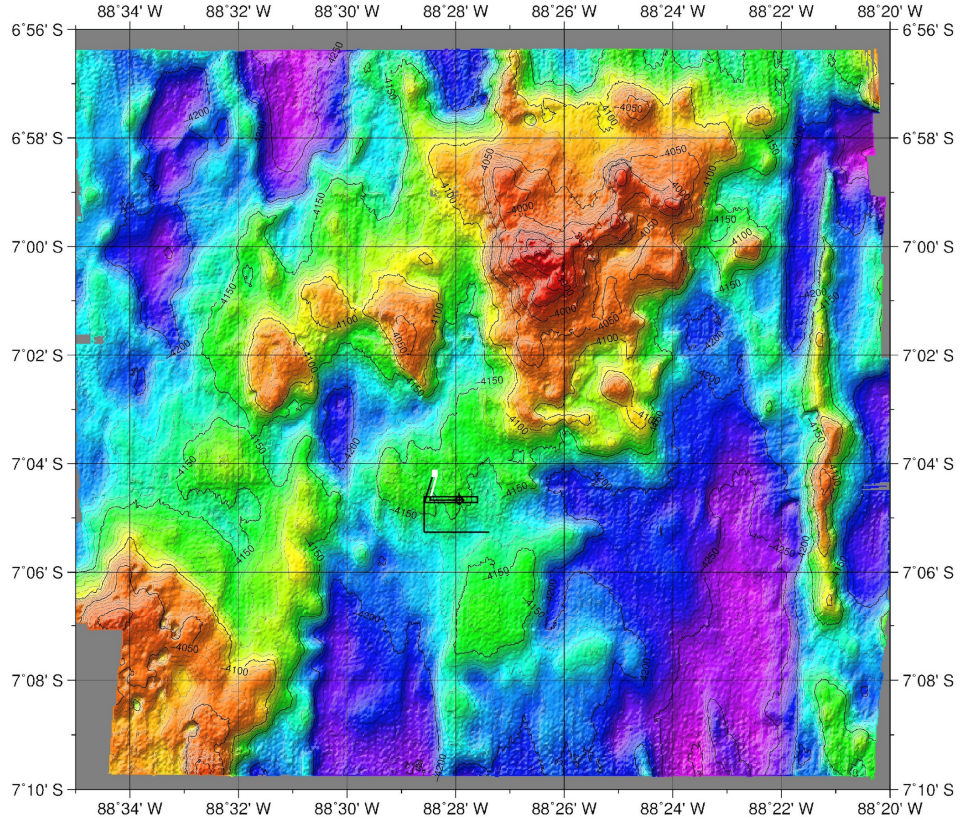


Figure 8.1.4.2: SO242-1_025_AUV3 (Abyss_189, DEA, 01.08.15, 1Hz) – 13,000 images (3,140 good). Notes: 0-4,320 (Water Col.) / 7,460-13,000 (Water Col.).

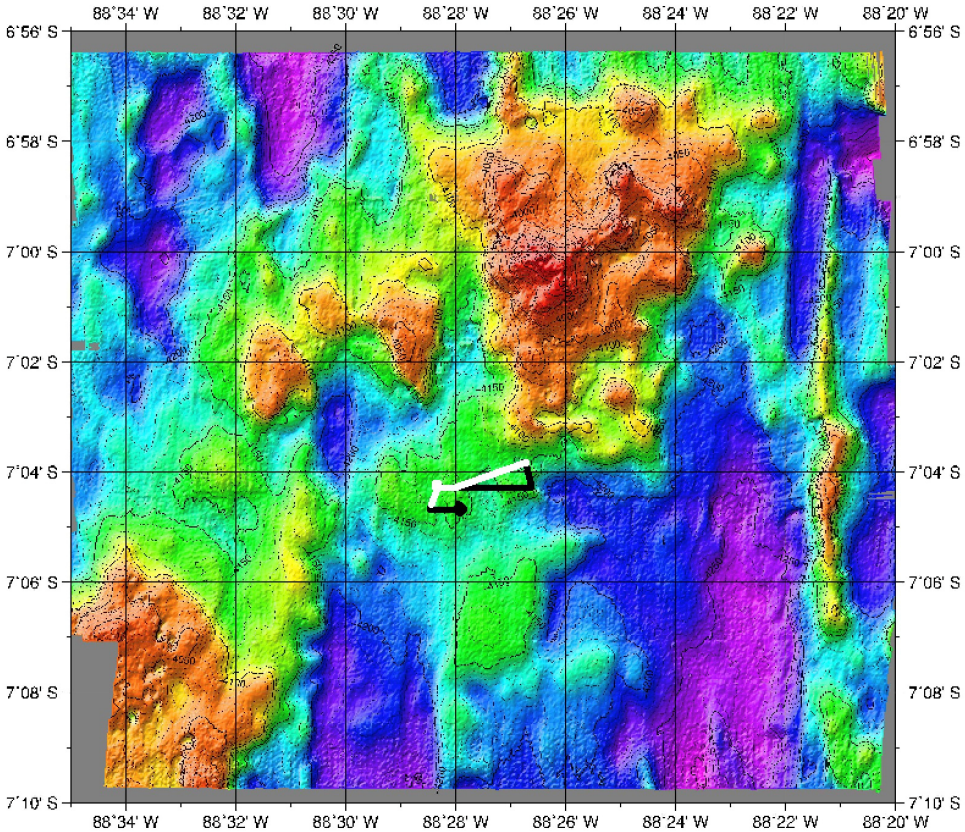


Figure 8.1.4.3: SO242-1_033_AUV4 (Abyss_190, DEA, 02.08.15, 1Hz) – 13,000 images (7,450 good). Notes: 0-3,190 (Water Col.) / 10,640-13,000 (Water Col.)

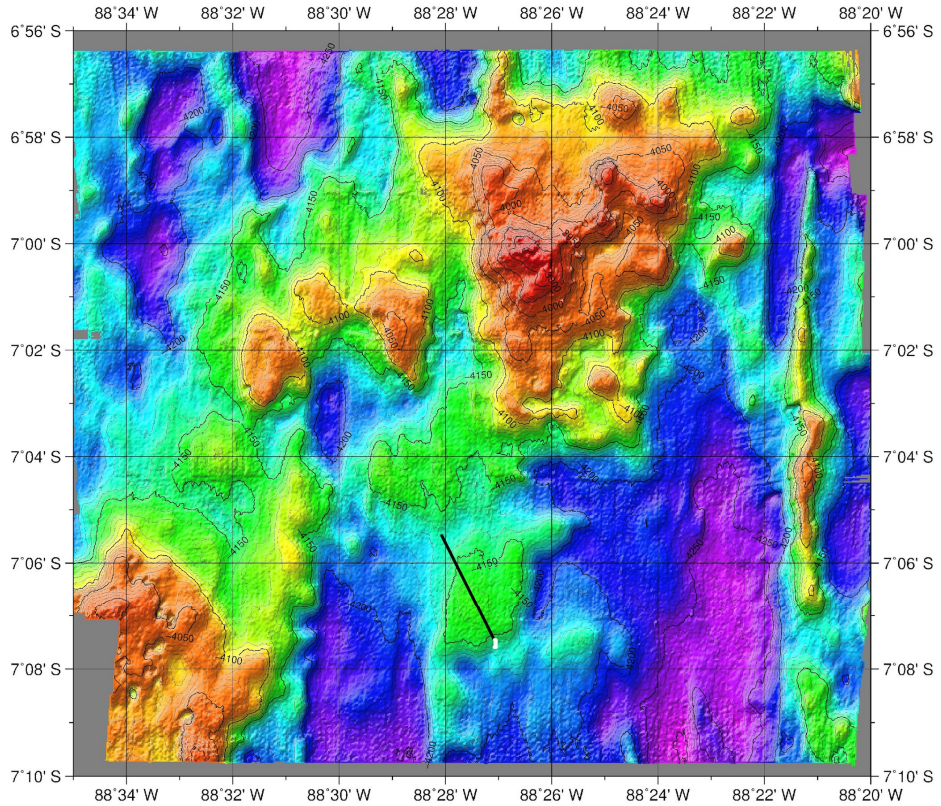


Figure 8.1.4.4: SO242-1_041_AUV5 (Abyss_191, Reference area South, 04.08.15, 1Hz) – 3,274 images (1,270 good). Notes: 0-2,000 (Water Col.) – after 3274 images, the camera broke and did not record any more images

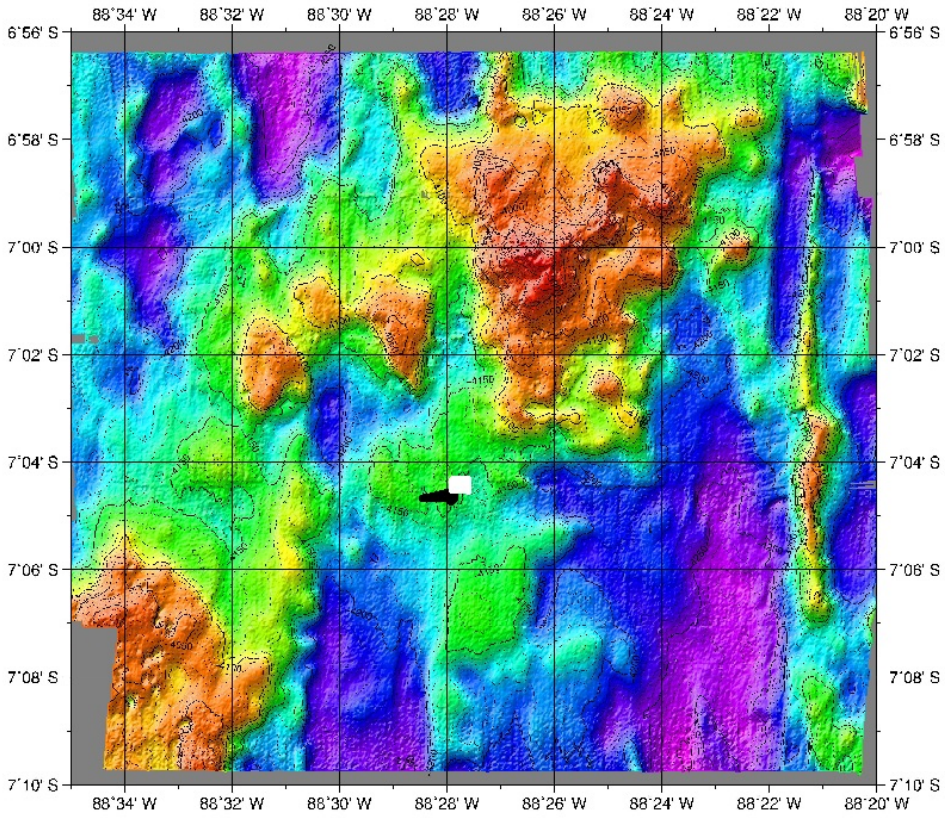


Figure 8.1.4.5: SO242-1_083_AUV10 (Abyss_196, DEA highly disturbed, 13.08.15, 1Hz) – 37,000 images (34,200 good). Notes: 0-2,800 (Water Col.)

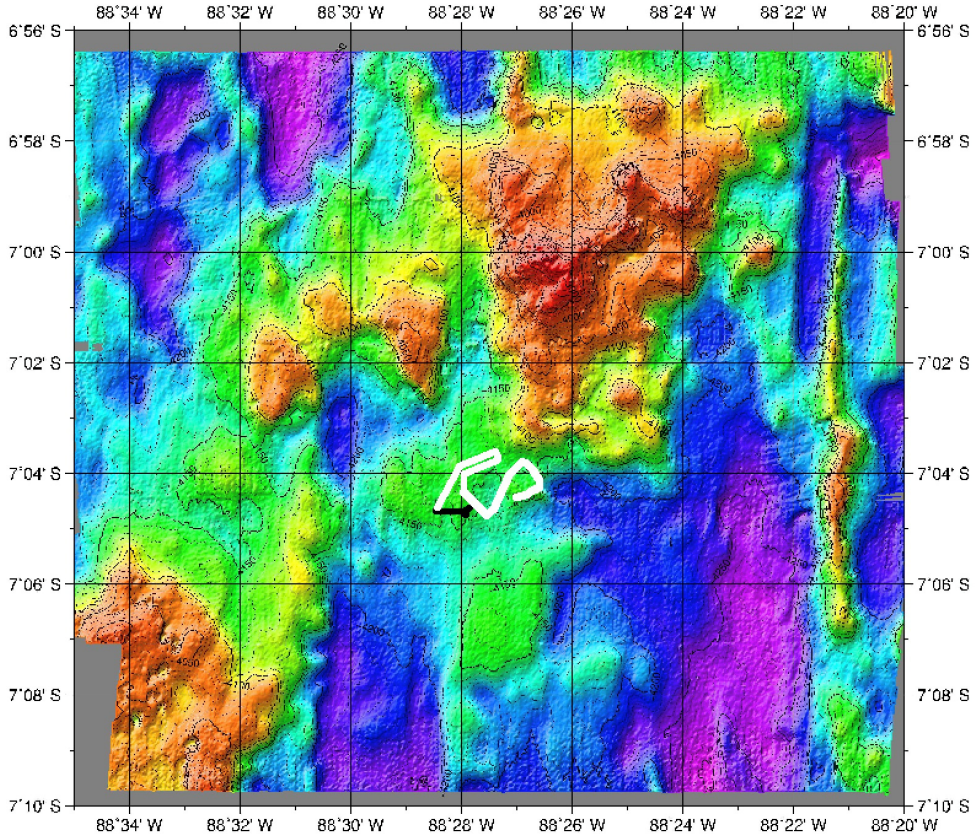


Figure 8.1.4.6: SO242-1_088_AUV11 (Abyss_197, DEA, 14.08.15, 1Hz) – 37,000 images (34,250 good). Notes: 0-1,237 (Water Col.), 35488-37000 (Water Column).

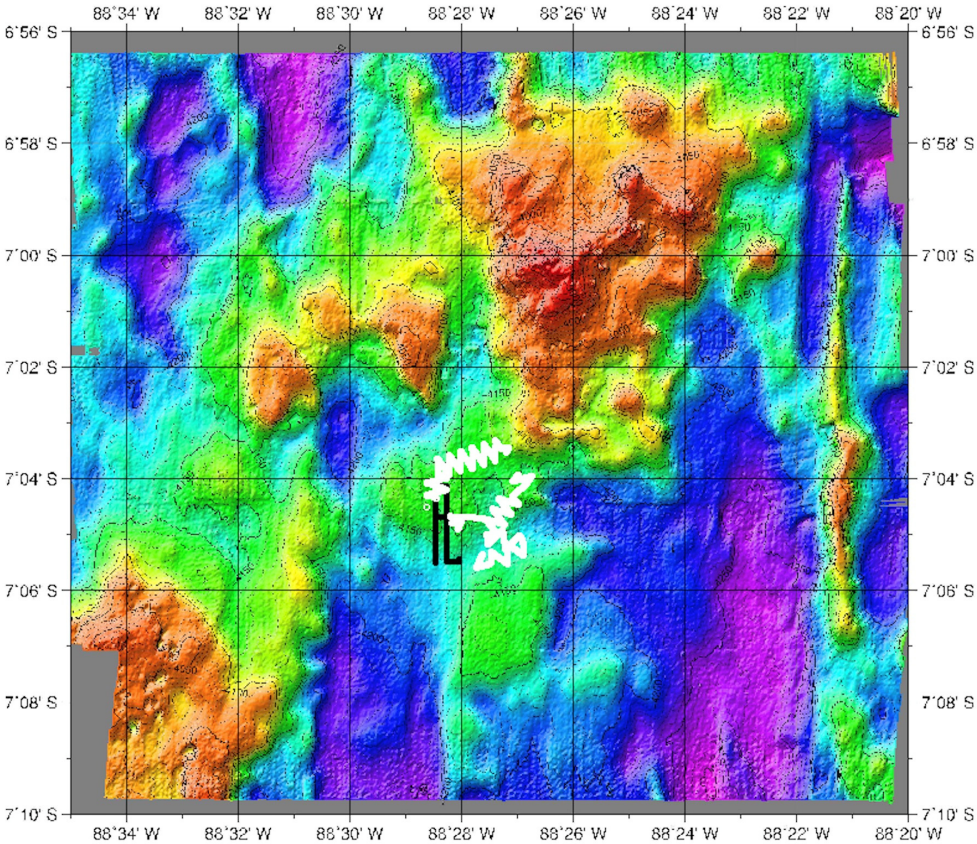


Figure 8.1.4.7: SO242-1_094_AUV12 (Abyss_198, DEA, 15.08.15, 1Hz) – 30,000 images (23,782 good). Notes: 23783 - 30000 (Water Column)

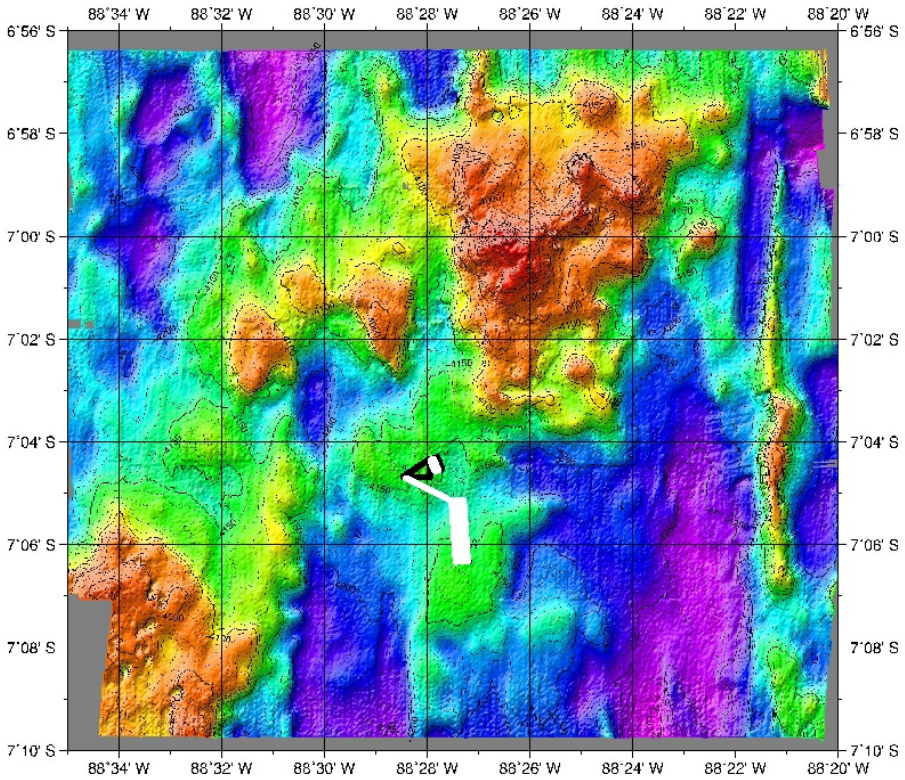


Figure 8.1.4.8: SO242-1_102_AUV13 (Abyss_199, Ref. South, 16.08.15, 1Hz) – 40,000 images (20,790 good) Notes: 0-652 (Water Column), 652 - 12538 (Condensation), 23651 - 24914 (Water Column), 34591 - 40000 (Water Column)

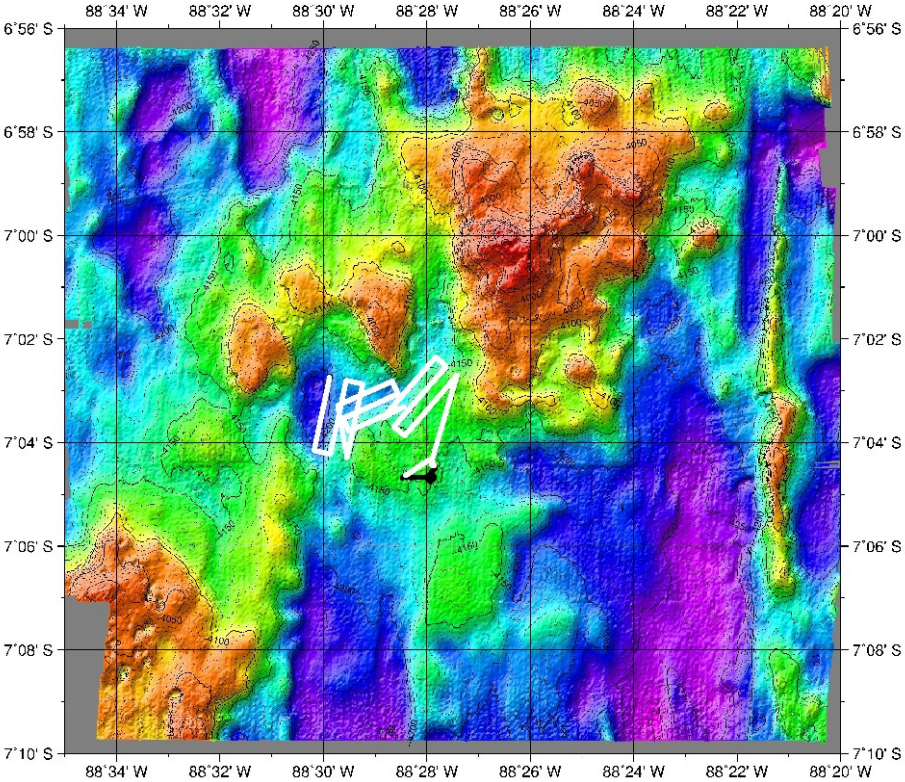


Figure 8.1.4.9: SO242-1_107_AUV14 (Abyss_200, 17.08.15, 1Hz) – 28,500 images (24,940 good) Notes: 0-2400 (Water Column), 27340 - 28500 (water Column)

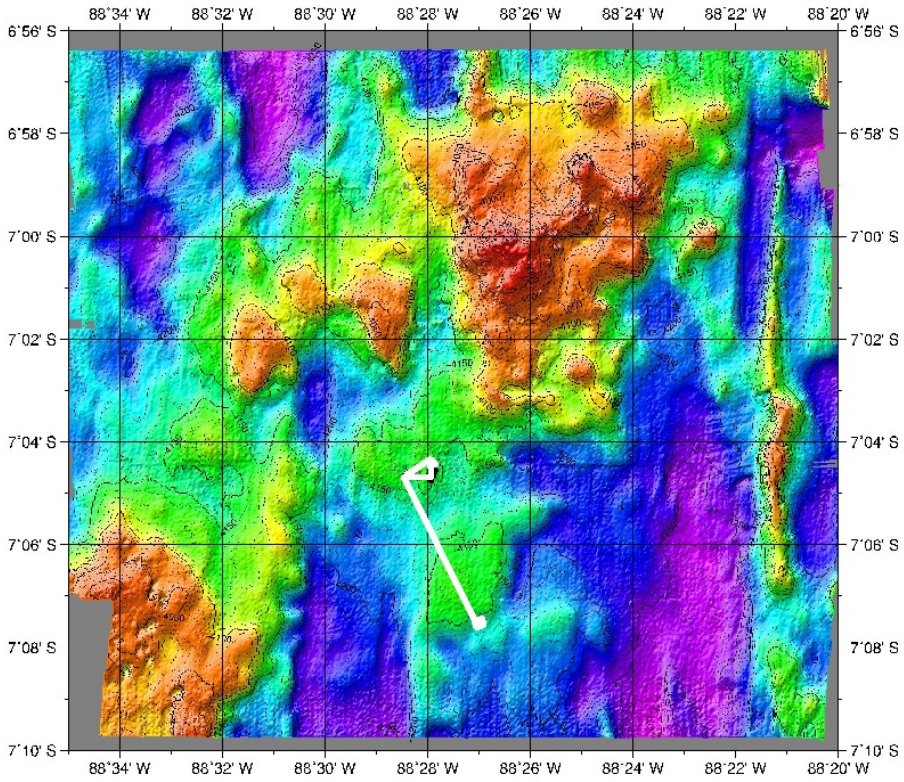


Figure 8.1.4.10: SO242-1_113_AUV15 (Abyss_201, 19.08.15, 1Hz) – 19,000 images (17,890 good). Notes: 0-860 (Water Column), 18750 - 19000 (Water Column), Cup-Bag often visible in top part of image

Image Management

In total, nine dives with camera were conducted. 220,774 images were acquired of which 167,716 are of good quality. After each dive with active camera setup, the data was transferred from the onboard hard disk to ship-based network-attached storage devices. Depending on the dive schedule, the transfer was conducted either via Ethernet (ca. 70 GB/h) by connecting the camera computer to the ships network or by disassembling the camera pressure bottle and retrieving the hard disk itself. Retrieving the hard disk is a time-consuming task (ca. 0.5h) but being able to copy the data from the hard disk via USB anyhow makes the whole process of data copying more efficient in most cases. The data was usually transferred to a portable USB hard disk first (ca. 700 GB/h) to be able to distribute the data to various target locations efficiently. Before distributing the data, the images where split up by time to subfolders, containing half an hour of images each (1800 images for the dives with 1Hz, 900 for those with 0.5 Hz). This step was necessary because even modern operating systems have difficulties to browse and display folders containing several ten thousands of files. After splitting, the first copy-target for the images is the image-processing computer that removes the image distortion caused by the employed fish-eye lens. This undistortion process takes less than a second per single image, as we use the graphics processing unit (GPU) for the undistortion, while the CPU undistortion had taken 6s per image. Thumbnails are generated alongside which takes another two seconds per image. On the employed processing computer (6 Cores, 3.5 GHz, 64 GB RAM) this step can be conducted in parallel in twelve processes and then takes around 1.9h per 10,000 (ca. 60 GB) images.

After calibration, the data was distributed to two of the NASs to provide access to the data for other scientists and to have a backup copy (ca. 2 x 350 GB/h). Also, the data was partly copied to the DIAS image annotation server (see Section 7.12). During duplication of the data, the log files of the AUV were manually merged with available image meta-data (Filename, File size, ISO value, etc.).

Therefore, first the data of the AUV state (roll, pitch, heading, temperature, turbidity, etc.) was merged with the ADCP data (altitude, latitude, longitude etc.) using the "Processing & Observations" tool in OFOP [CITE]. The available numerical data was splined to create one data-point per second. Afterwards the image data was added to this data array per time-stamp. The raw logs, as well as the merged and splined array, was saved alongside the images for long-time archival. This manual process takes ca. half an hour. Afterwards, the images were added to the ship-based annotation software DIAS. Therefore, each dive was added as a project and each half-hour folder as a transect to the PostgreSQL database. Here, the thumbnails are required to provide a reasonably quick overview for the annotators. Adding the data to DIAS by parsing the files and accompanying splined log files takes ca. 5 minutes.

The complete pipeline from the AUV through all processing and copying steps to the final availability through the NASs and DIAS takes 0.55h per dive plus 22.5 min / GB i.e. ca. 22.3 h / 10,000 images. As some of the steps (Fish-Eye correction, Thumbnail generation) were conducted in parallel, this results in 7.3 days of continuous image processing for the annotation and archival preparation alone (on a single core computer it would have taken 23.2 days). Following steps like illumination correction, pattern recognition or mosaicking are not included! To prevent data loss through baggage loss or disaster, the NASs were split up after the cruise between different flights and containers. Three of the participating institutions (Senckenberg, GEOMAR, Uni Bielefeld) received one copy of the data each. The data was made available online, again using the web-based annotation software DIAS [CITE] for continued manual annotation of objects of interest. The annotation database created onboard RV SONNE was made available through the server in Bielefeld and will be duplicated on the servers at the other two institutions.

Photo mosaicking

In total six photo mosaicking surveys aiming to completely map a rectangular area where performed. Two separate areas, the southern reference site as well as the central part of the DEA were targeted (see also chapter 8.1.1). In a very first mosaicking approach processed AUV images were projected to scale on a plane using the AUV-derived position and orientation data as only source for georeferencing. AUV dive 191 (SO242/1_#41_AUV-5) surveyed the southern reference site, unfortunately the camera broke after half of the survey and the mapped area was smaller than planned. The preliminary mosaic is shown in Figure 8.1.4.1. The seafloor is not as densely covered by Mn-nodules and old as well as new sampling locations could be detected. A second dive (201; SO242/1_#113_AUV-15) to the southern reference site at lower altitude (4m) was performed allowing to evaluate the differences when annotating from different altitudes.

In the central DEA the western sampling site for a heavily disturbed seafloor was focus of four photo mosaic surveys. The first survey (#83_AUV-10 Dive 196) with an altitude of 7m covered a very large area of about 600 by 400m (Figure 8.1.4.2). Based on the AUV-bathymetric information a second dive to the same area was conducted during station #102_AUV-13 (dive 199) in only 4.5m altitude (Figure 8.1.4.3) and a third survey followed with only 4m distance (#107_AUV-14 dive 200).

For comparison reasons between AUV imagery and OFOS data, station #88_AUV-11 (dive 197) followed an old OFOS track in 7m altitude with 7 parallel lines (see Figure 8.1.1.18) following an old OFOS track and parts of the OFOS track undertaken during station SO242/1_#43_OFOS-1 (see chapter 8.1.5). All images will upload in DIAS as georeferenced and scaled data. The images will be available for partners of the JPIO project and later on will be made publically available. After the cruise additional re-navigation of the position information and machine vision processing will hopefully generate complete mosaics in which images are correct aligned to each other and artefacts

of the image illumination are reduced below the visible limit. The final mosaics will be jointly analyzed with biologist from Portugal and the UK as well as people from the AWI using additionally OFOS and ROV data acquired during SO242/2.

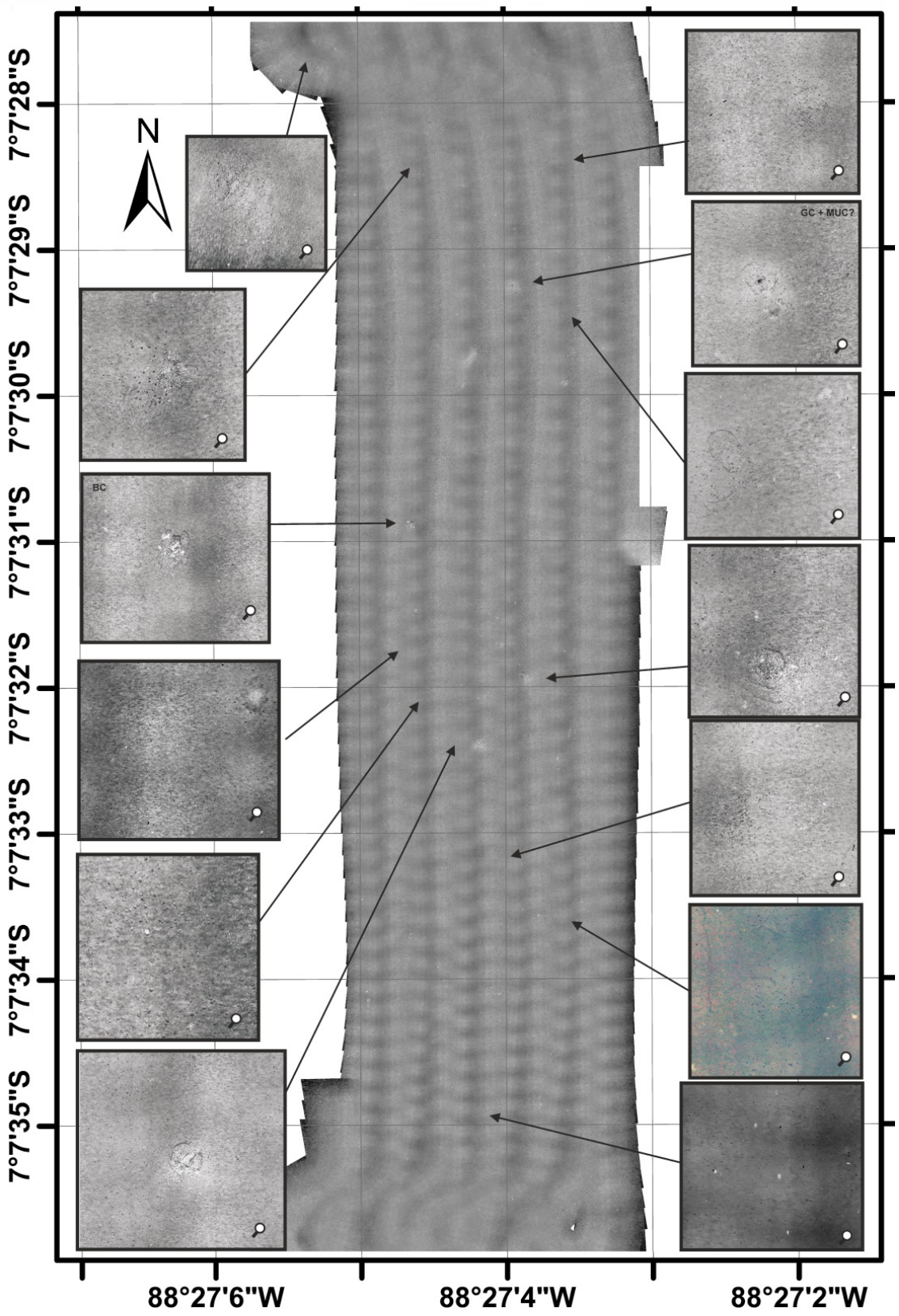


Figure 8.1.4.1: First photo mosaic from AUV dive 191 in the southern reference area.

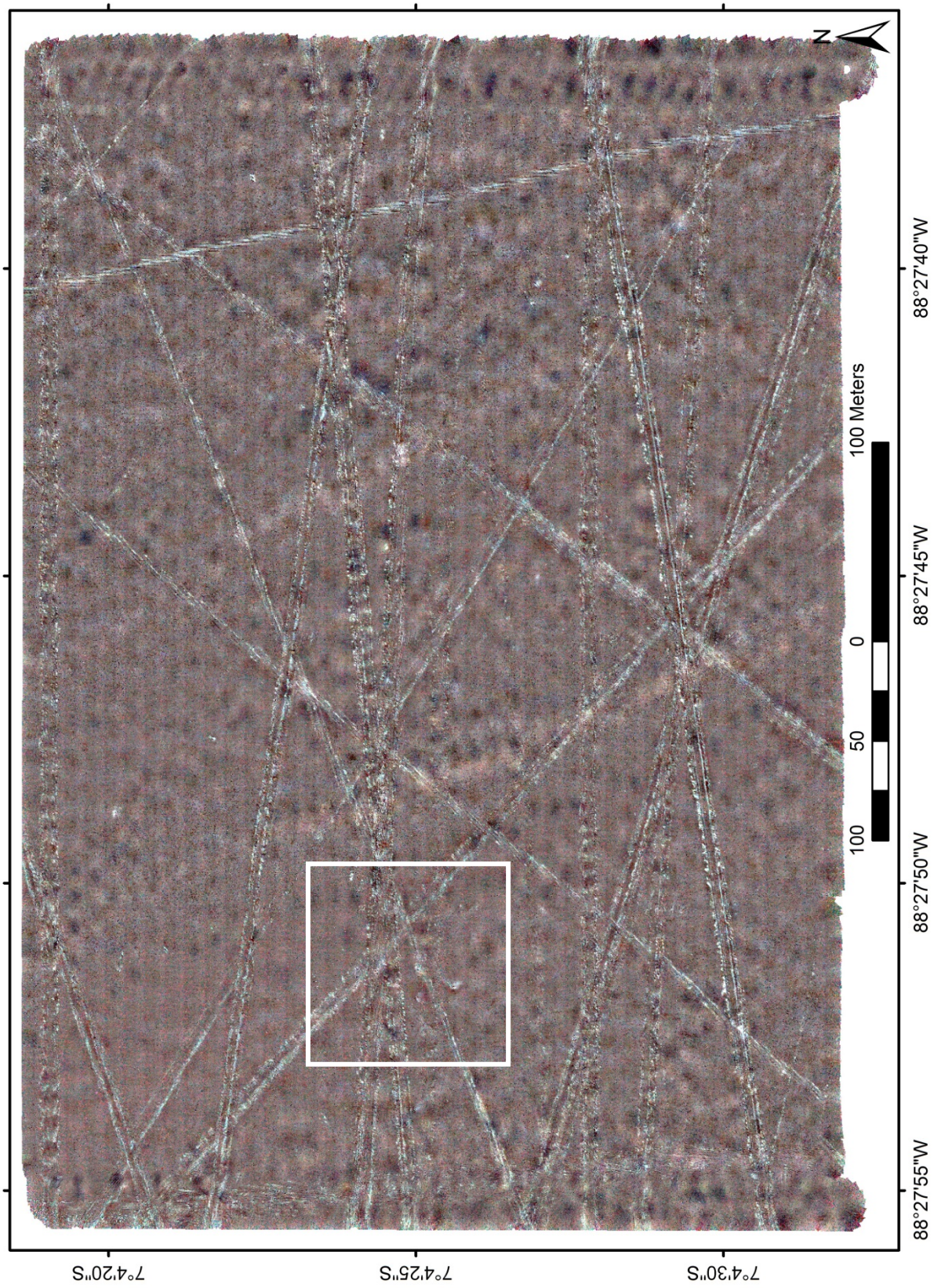


Figure 8.1.4.2: Preliminary phot mosaic of AUV dive 196. Clearly crisscrossing plough marks can be seen having different width and relief. The white rectangle indicates the western heavily disturbed area in the DEA. North is to the left.

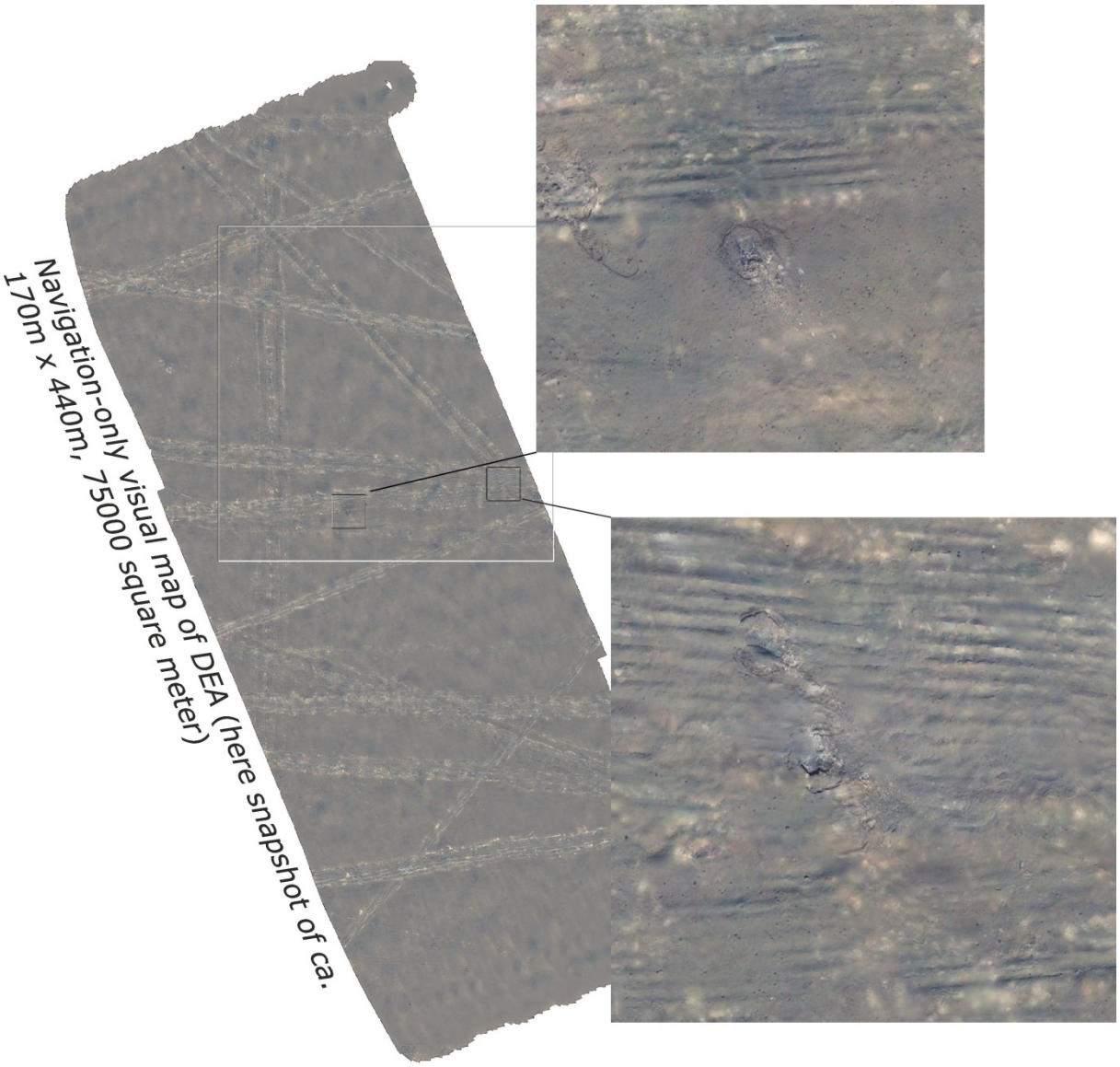


*Figure 8.1.4.3: Preliminary results of AUV d*ive 199 mapping the heavily disturbed western area within the DEA. As the dive was run after MUC and BC sampling happened, clear signs of the sample locations can be seen, showing that some of the BC clearly hit the plough marks thanks to the very accurate USBL navigation.

8.1.5 Seafloor observations

José Nuno Gomes-Pereira, Erik Simon Lledo, Jens Greinert, Kevin Köser, Evangelos Alevizos,

A total of 6 OFOS dives were completed, during the cruise SO242-1, totalling 27:47 hours of bottom time, recorded on video, extending over 21170m long and ca. 47322 m^2 of which at least 6000 m^2 were over disturbed stratum (over plough marks). A total of aproximately 3800 megafaunal records were obtained. The most abundant taxa were the parapaguridae *Probeebei mirabilis*, different holothurian species, sponges, actinians, ophiuroids, xenophyophora, pelagic shrimps and the *Ipnops* sp. fish. Information regarding each dive is summarized in the end of this section. An area near the centre of the DEA was surveyed on two occasions at different heights and will allow comparison with imagery collected by different survey platforms and configurations.

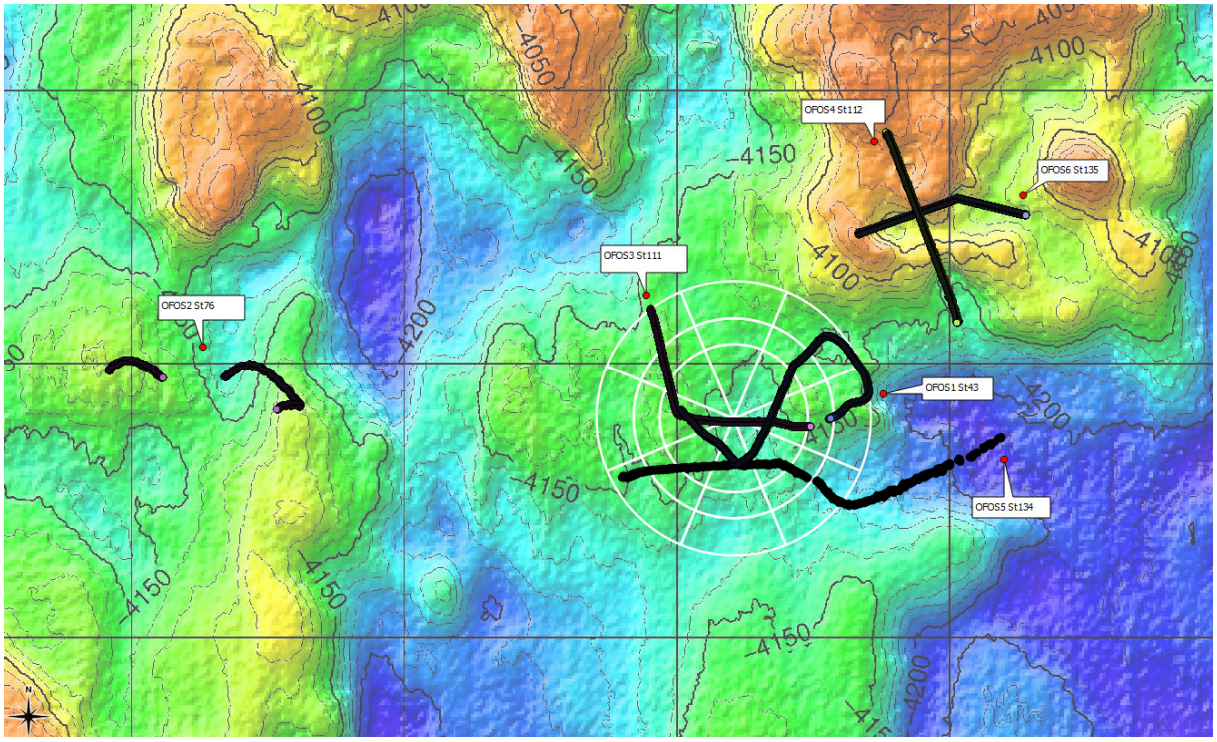


Figure 8.1.5.1: OFOS dive locations during SO242-1 with indication of the DEA sectors

Jens Greinert was responsible for the OFOS set up, telemetry units and data workflow. Megafaunal annotations and selection of sites and camera disposition for megafauna assessment were performed by Erik Simon Lledo and Jose Gomes Pereira. Kevin coordinated the stereo camera deployment and illumination. Evangelos was responsible for using the plough mark observations to correct the side-scan image, the definition and characterization of the seafloor morphology in OFOS survey dives in the northern part.

The first OFOS survey was developed to correct the side-scan sonar map image of the entire DEA area collected by the AUV to assist further surveys. This was done by ground through of the plough marks detected by the side-scan. It also allowed to investigate the presence of nodules in dark large patches obtained in the side-scan image and collect preliminary data for megafaunal assessment and survey planning. The second OFOS dive was performed in the Western reference area. Wave and wind conditions and software configurations hampered the quality of data in terms of geopositioning and image definition and these were overcome in the following dives. In the third and fifth dive (OFOS3 and 5), the areas with plough marks inside the DEA were investigated. In dive OFOS5 the transect crossed the entire DEA and reached the Eastern area without nodules. In the OFOS4 and 6 dives the area north of the DEA was investigated.

Table 8.1.5.1. General Dive information, with indication of dive length and area covered

Date	#Station	Dive code	Location	Bottom time	Total Length (m)	horizontal field of view	aprox. area (m2)
3-Aug-2015	43	OFOS1	DEA	8:49:32	5485	2.86	12067
18-Aug-2015	76	OFOS2	West Reference	2:35:52	1558	2.86	4456
18-Aug-2015	111	OFOS3	DEA Plough Marks	4:08:28	3379	1.91	6454
18-Aug-2015	112	OFOS4	North Mountains	3:11:37	2834	2.86	8105
22-Aug-2015	134	OFOS5	DEA Plough Marks To East No-Nodule Reference	5:42:24	5523	1.91	10549
23-Aug-2015	135	OFOS6	North Mountains II	3:19:20	2391	2.38	5691

Table 8.1.5.2. General Dive information, with indication of dive start and end.

Name	Start time	Depth	Lat	Lon	End time	Depth	Lat	Lon
OFOS1	3:48:15	4142	-88.466222	-7.072387	12:37:47	4146	-88.447909	-7.073378
OFOS2	11:56:10	4131	-88.536082	-7.067517	14:32:02	4141	-88.516326	7.067944
OFOS3	12:57:57	4137	-88.469914	-7.06	17:06:25	4162	-88.450977	-7.074372
OFOS4	20:49:56	4089	-88.441047	-7.0383	0:01:34	4161	-88.432837	-7.059589
OFOS5	22:21:39	4148	-88.457827	-7.0791	4:04:04	4190	-88.426971	-7.076364
OFOS6	7:41:58	4067	-88.444035	-7.0509	11:01:18	4122	-88.424178	-7.048421

OFOS Dive: 242-1_#43_OFOS1

Station: #43
Date: 3 August 2015
Location: DEA
Bottom time: 08:49:32
Length: 5485 m
Image System Setup, Survey method and Data processing
Video Camera Model: Oktopus GmbH Colour
Survey method and equipment: Preliminary survey covering different substrate types. Cable attached to frame 1.8m long. The camera system was setup specifically for this dive. Se gear specifications for more details. The distance was kept regular around 1m from the seafloor,

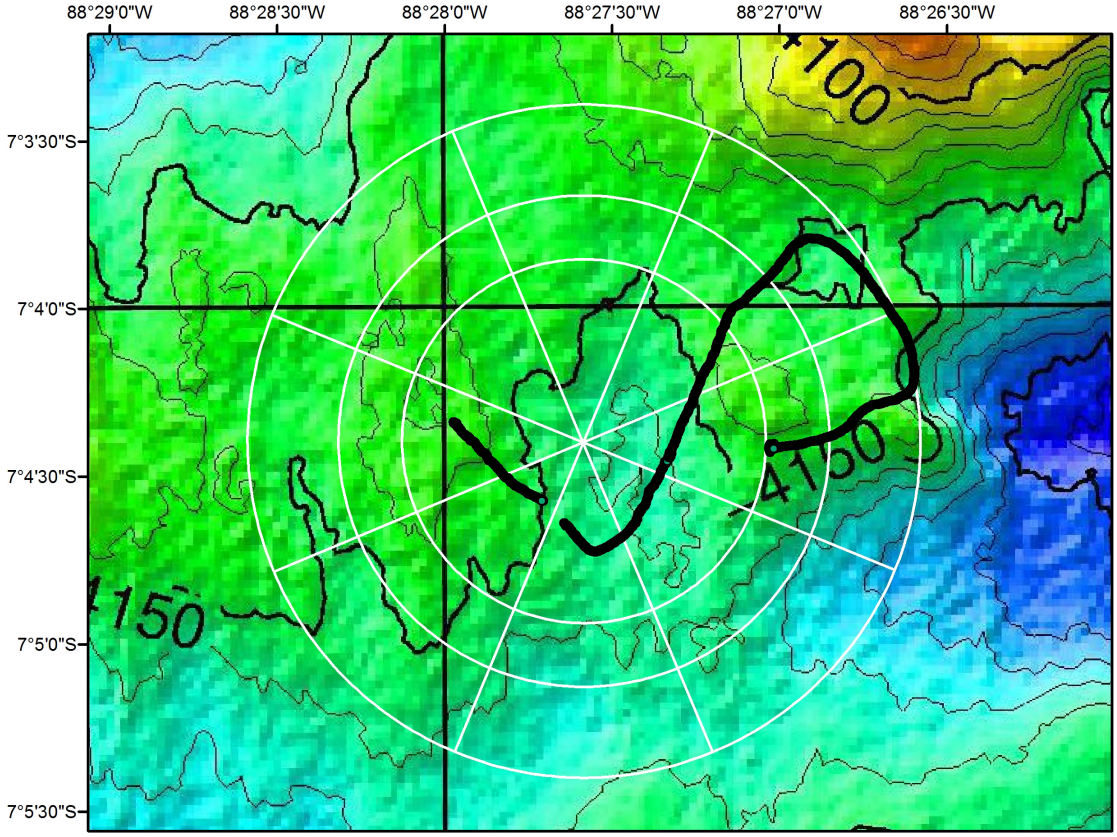
ranging mostly between 1 and 1,5, using the shadow of the weight on the upper left corner of the screen.

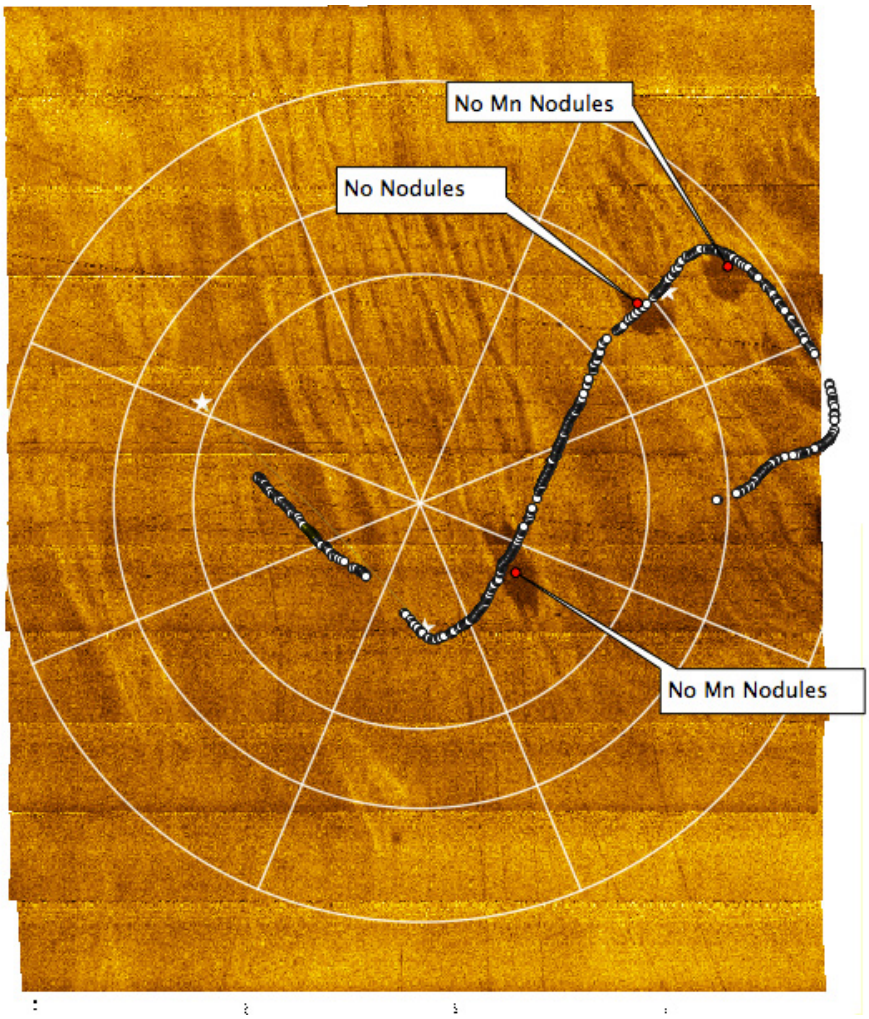
Navigation processing: Navigation was processed using OFOP smoothing (moving average) and spline data to the second.

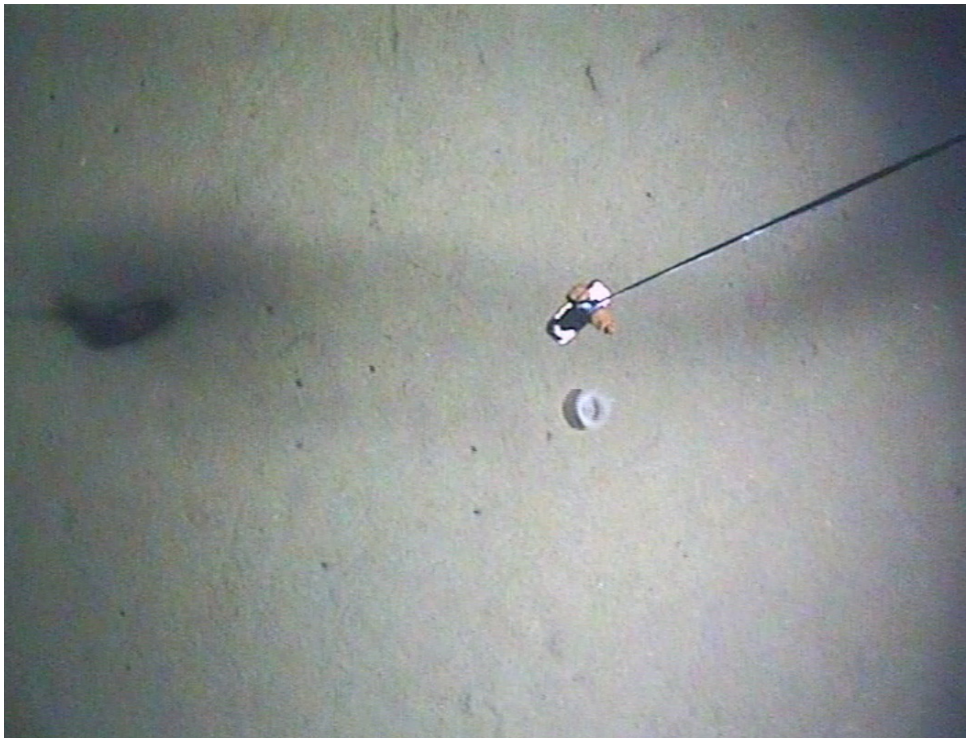
Objective & Resume:

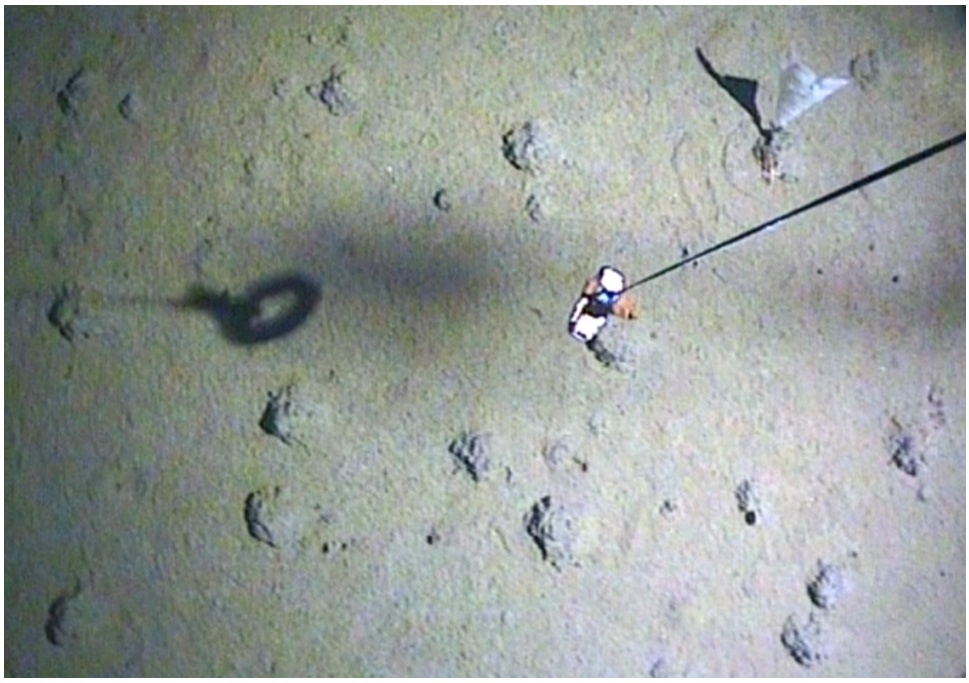
The first dive was developed to i) groundtruth plough marks map generated based on side-scan sonar of the AUV, to allow correction of the image of the entire DISCOL area; ii) cover particular areas of interest, such as dark large patches in the side-scan image; iii) and collect preliminary data for megafaunal assessment and survey planning. The transect also crossed an area of benthic surveys near the centre of the DEA for comparison with other surveying techniques.

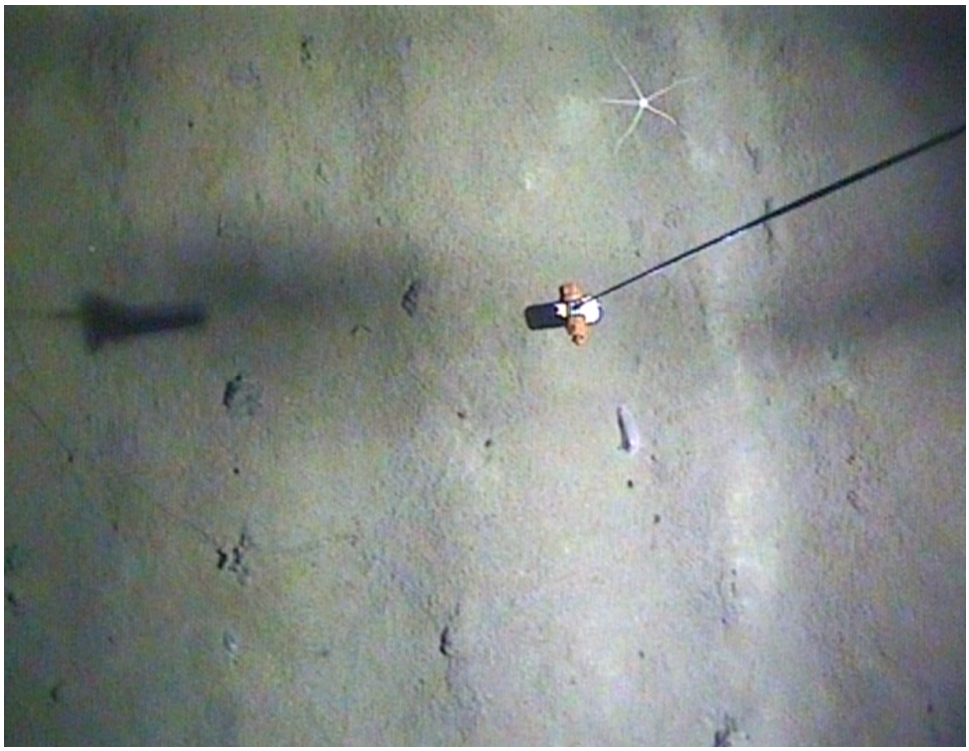
Figure of dive transect 242-1_#43_OFOS-1




No Mn Nodules
No Nodules
No Mn Nodules







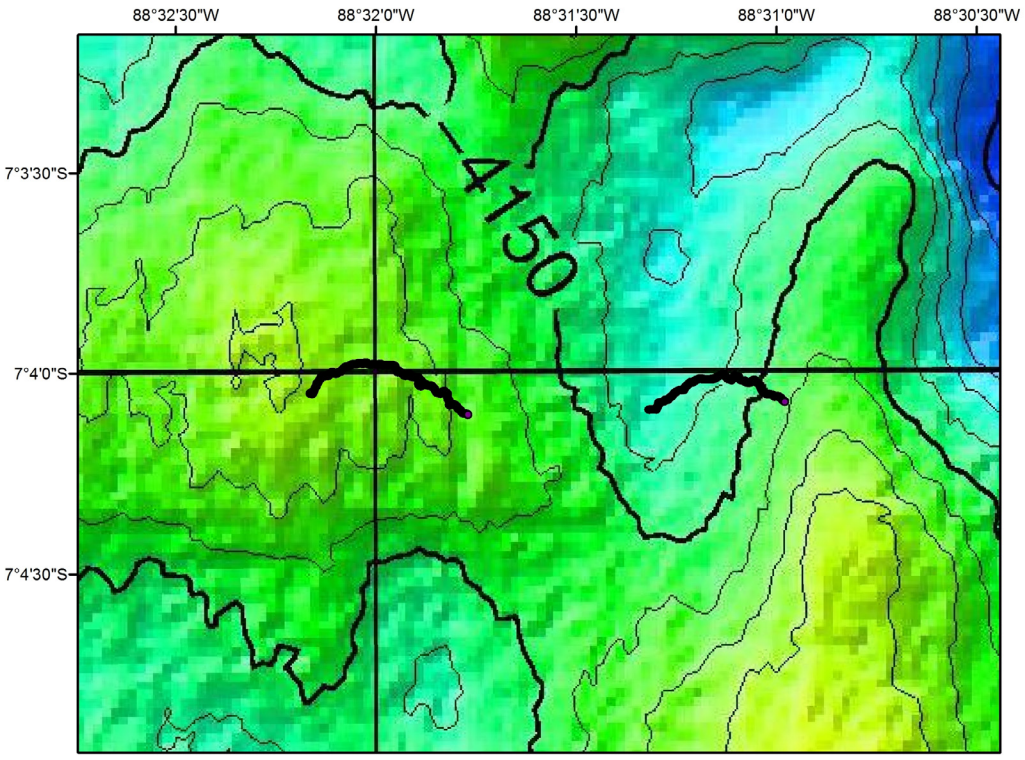
OFOS Dive Code: 242-1_#76_OFOS2

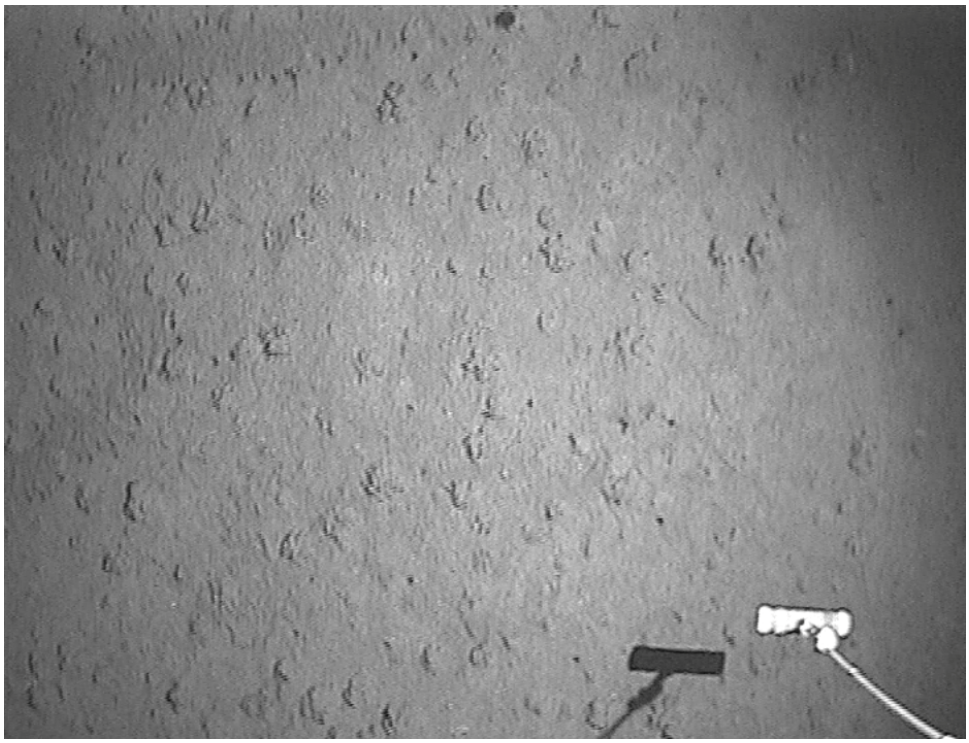
Station: #76
Date: 12 August 2015
Location: West reference site
Bottom time: 02:35:52
Length: 1559 m
Image System Setup, Survey method and Data processing
Video Camera Model: Oktopus GmbH Colour
Survey method and equipment: OFOS towed with vertical/downward camera at 2.5 – 3 m. A compass of 2.5 m (including weight was included in the system) (see gear specifications for more details). Two stereo cameras were set up around the video camera, collecting 1 image per second. Real-time annotations were performed with the Ocean Floor Observation Protocol software, and recorded together with ship and sub navigation. An additional computer running OFOP as a client was used for the annotations, receiving ship and sup information streamed via intranet. Time in UTC. Only Black & White video was recorded, despite the computer recording the video signal that was being captured was displaying a colour image.

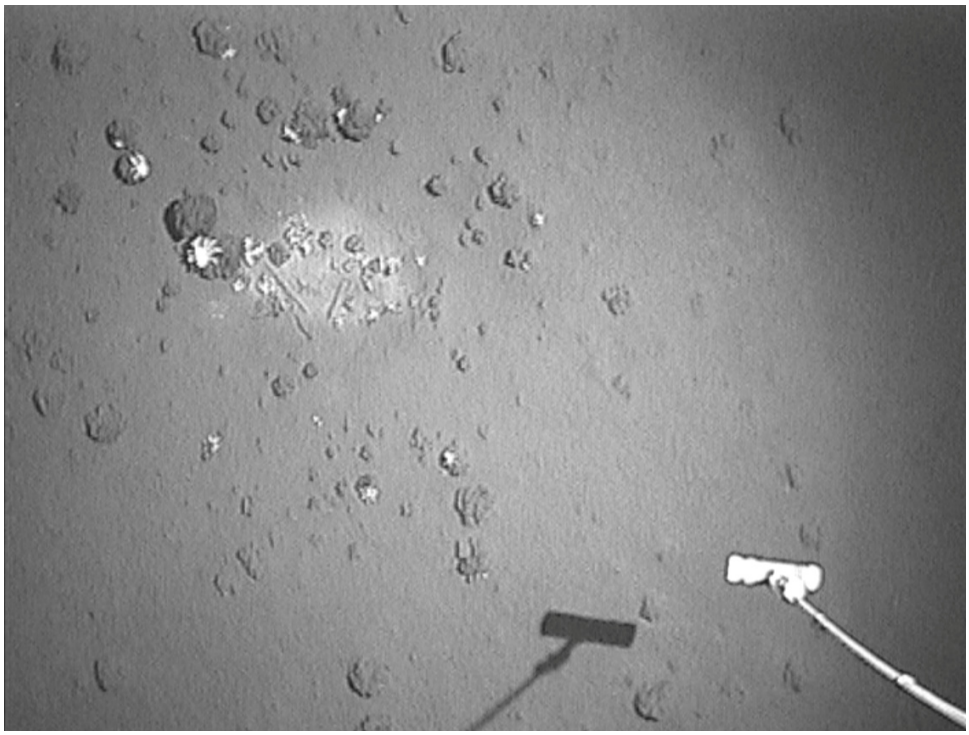
Navigation processing: The USBL did not communicated constantly with the ship. On the first out of four transects, the ship multi-beam was on, and might have additionally affected the positioning system. This was turned off on the following transects. However, the USBL position was of very low quality and only reliable on transects 2 and 4. The transects 1 and 3 were oriented 45º NE and the USBL did not work, possibly because the ship needed to use two trustees to move in that direction, creating water movement and bubbles affecting the quality of the USBL Posidonia communication. Two transects had reliable navigation, Transect 2 from 11:57:40 to 12:55:00, and transect 4, from 13:52:01 until 14:32:03. The transects were also not as straight as intended, as it was difficult to keep the OFOS following a predetermined track. Navigation was processed using OFOP smoothing (moving average) and spline data to the second. A smooth of 131 held the most realistic results in comparison with the navigation as observed on the screen.
Objective & Resume:
The dive was performed to collect quantitative data on megafauna and develop tests with a stereographic camera system. The area of survey was the West Reference Area.

The dive started with the tests for the stereo-cameras, using a fixed position. Four transects were accomplished. A gradual increase in speed was performed, starting from 0.25 knot/h taking longer in the first transect. Transects 1 and 2 were developed at 1k/h, and 3 and 4 at 0.8 k/h.
Large sections with a considerably high number of nodules, and from mid ownwards, a different section with many and smaller nodules. Highlights: aggregation of different crustacean on food fall.

Figure of dive transect 242-1_#76_OFOS-2







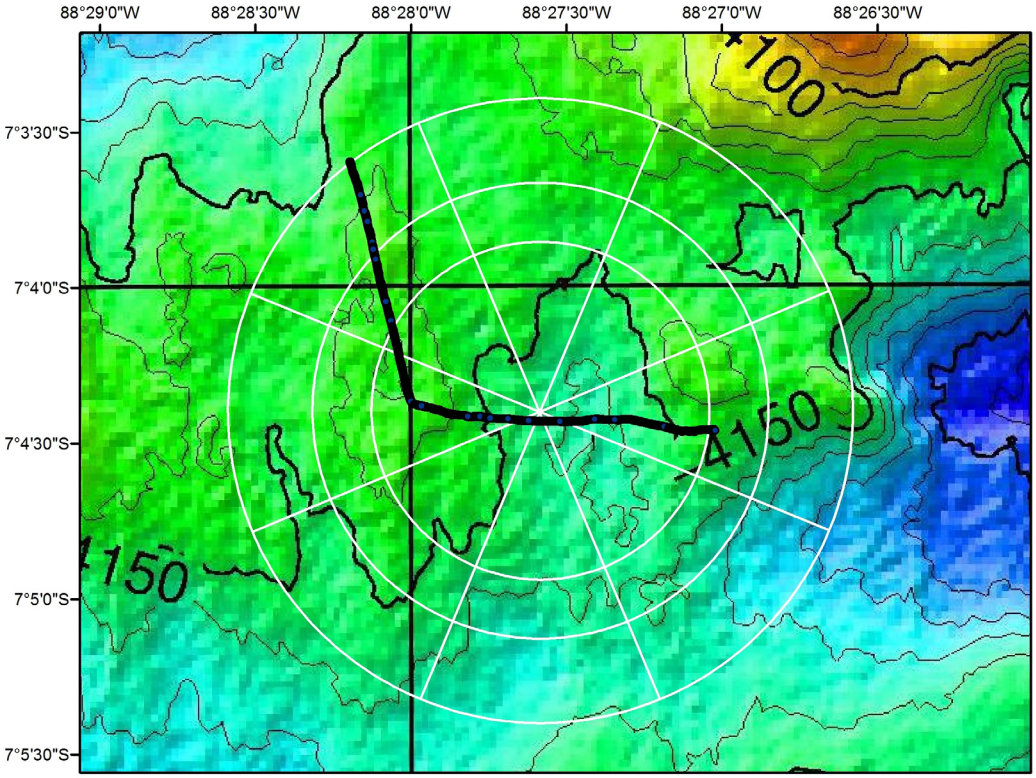
OFOS Dive Code: 242-1_#111_OFOS3

Station: #111
Date: 18 August 2015
Bottom time: 4:08:28
Length: ca.6454 m
Image System Setup, Survey method and Data processing
Video Camera Model: Oktopus GmbH Colour
Survey method: OFOS towed with vertical/downward camera at 1,6 – 2 m. A compass of 1.5 m (including weight was included in the system) (see gear specifications for more details). Two stereo cameras were set up around the video camera, collecting 1 image per second. Real-time annotations were performed with the Ocean Floor Observation Protocol software, and recorded together with ship and sub navigation. An additional computer running OFOP as a client was used for the annotations, receiving ship and sup information streamed via intranet. Time in UTC.

Navigation processing: A smooth of 10(21) was considered to provide the most realistic OFOS track using the video imagery as a reference.

Objective & Resume:
In this dive we aimed to follow plough mark tracks to establish comparison between this stratum and the others. Almost half of the dive (1.8km approx.) did successfully dive along these areas. Preliminary analysis indicates some variation in fauna between both strata. The transect crossed an area of benthic surveys that was previously crossed during OFOS1 near the centre of the DEA for comparison with other surveying techniques.

Figure of dive transect 242-1_#43_OFOS-3



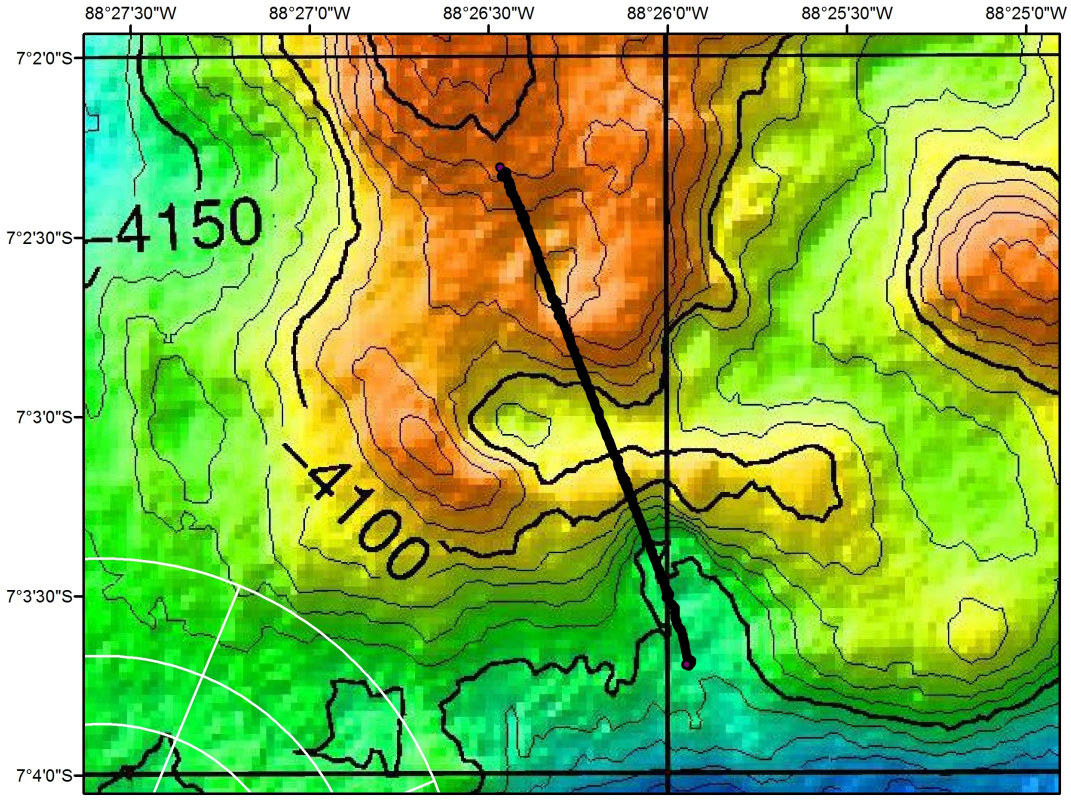
OFOS Dive Code: 242-1_#112_OFOS4

Station: #112
Date: 18 August 2015
Duration: 03:11:37
Length: 8150 m
Image System Setup, Survey method and Data processing
Video Camera Model: Oktopus GmbH Colour
Survey method: OFOS towed with vertical/downward camera at 2,1 – 2,5 m. A compass of 2,5 m (including weight was included in the system) (see gear specifications for more details). Two stereo cameras were set up around the video camera, collecting 1 image per second. Real-time annotations were performed with the Ocean Floor Observation Protocol software, and recorded together with ship and sub navigation. Geological annotations were performed in the lab screen. An additional computer running OFOP as a client was used for megafauna annotations, receiving ship and sup information streamed via intranet. Time in UTC.
Navigation processing: Navigation was processed using OFOP smooth and spline.

Objective & Resume:
The dive was developed in a roughed area north of the DEA. The objectives included characterization of seafloor types across variable bathymetric features and identification of megafaunal component. These features include seamounts, slopes, caldera-shaped formations and local elevations of interest. The OFOS data will support a comprehensive interpretation in terms of benthic habitats.

OFOS interpretation during recording included both identification of megafauna and geological features simultaneously. Regarding the different geological types found along the track these consist mainly of: A) soft sediment covered with either talus debris or variable densities of Mn-nodules at places (generally it was difficult to distinguish the high density Mn-nodules from talus debris although talus has a more angular shape). B) Pillow basalts and basalt boulders at and near the very steep slopes which appear covered by a thin layer of soft sediment. C) Soft sediment without apparent features mainly within small depressions. Overall it is inferred that soft sediments of variable thickness with or without talus debris cover the local seamounts which consist of pillow basalts. The thickness of the unconsolidated sediments decreases significantly towards the steep slopes where is minimized or even absent. Particularly near the end of the track the basalt structure which is attributed to a local elevation of 10 meters, appears totally uncovered by sediments. At places with smooth or no slope soft sediments seem to be covered by Mn-nodules but this needs to be further examined to avoid confusion with talus debris. Finally, local depressions probably act as sediment traps hence capturing increased thickness of sediments potentially with buried talus debris.

Figure of dive transect 242-1_#112_OFOS-4



OFOS Dive Code: 242-1_#134_OFOS5

Station: #112

Date: 18 August 2015

Duration: 05:42:24

Length: 10549 m

Image System Setup, Survey method and Data processing

Video Camera Model: Oktopus GmbH Colour

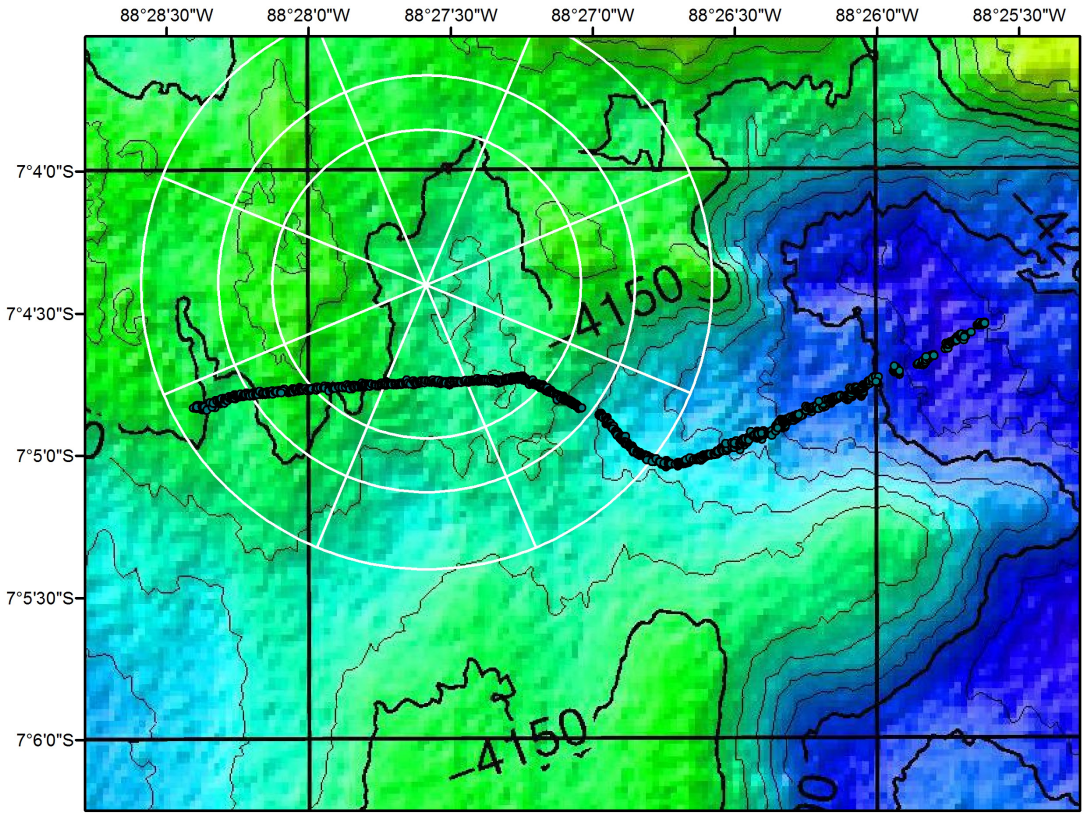
Survey method: OFOS towed with vertical/downward camera at 2,1 – 2,5 m. A compass of 1,5 m (including weight was included in the system) (see gear specifications for more details). Two stereo cameras were set up around the video camera, collecting 1 image per second. Real-time annotations were performed with the Ocean Floor Observation Protocol software, and recorded together with ship and sub navigation. Geological annotations were performed in the lab screen. An additional computer running OFOP as a client was used for megafauna annotations, receiving ship and sup information streamed via intranet. Time in UTC.

Navigation processing: Navigation was processed using OFOP smooth and spline..

Objective & Resume:

The dive was developed south in the southern sectors of the DEA following plough marks. The dive aimed to cross the entire DEA sector, and followed towards a No-Nodule area on East of the DEA to be used as a reference site to compare with no nodule areas inside the DEA. This area was reached just before the end of the dive.

Figure of dive transect 242-1_#134_OFOS-5



OFOS Dive Code: 242-1_#135_OFOS6

Station: #112

Date: 18 August 2015

Duration: 03:19:20

Length: 5691 m

Image System Setup, Survey method and Data processing

Video Camera Model: Oktopus GmbH Colour

Survey method: OFOS towed with vertical/downward camera at 2,1 – 2,5 m. A compass of 2 m (including weight was included in the system) (see gear specifications for more details). Real-time annotations were performed with the Ocean Floor Observation Protocol software, and recorded together with ship and sub navigation. Geological annotations were performed in the lab screen. An additional computer running OFOP as a client was used for megafauna annotations, receiving ship and sup information streamed via intranet. Time in UTC.

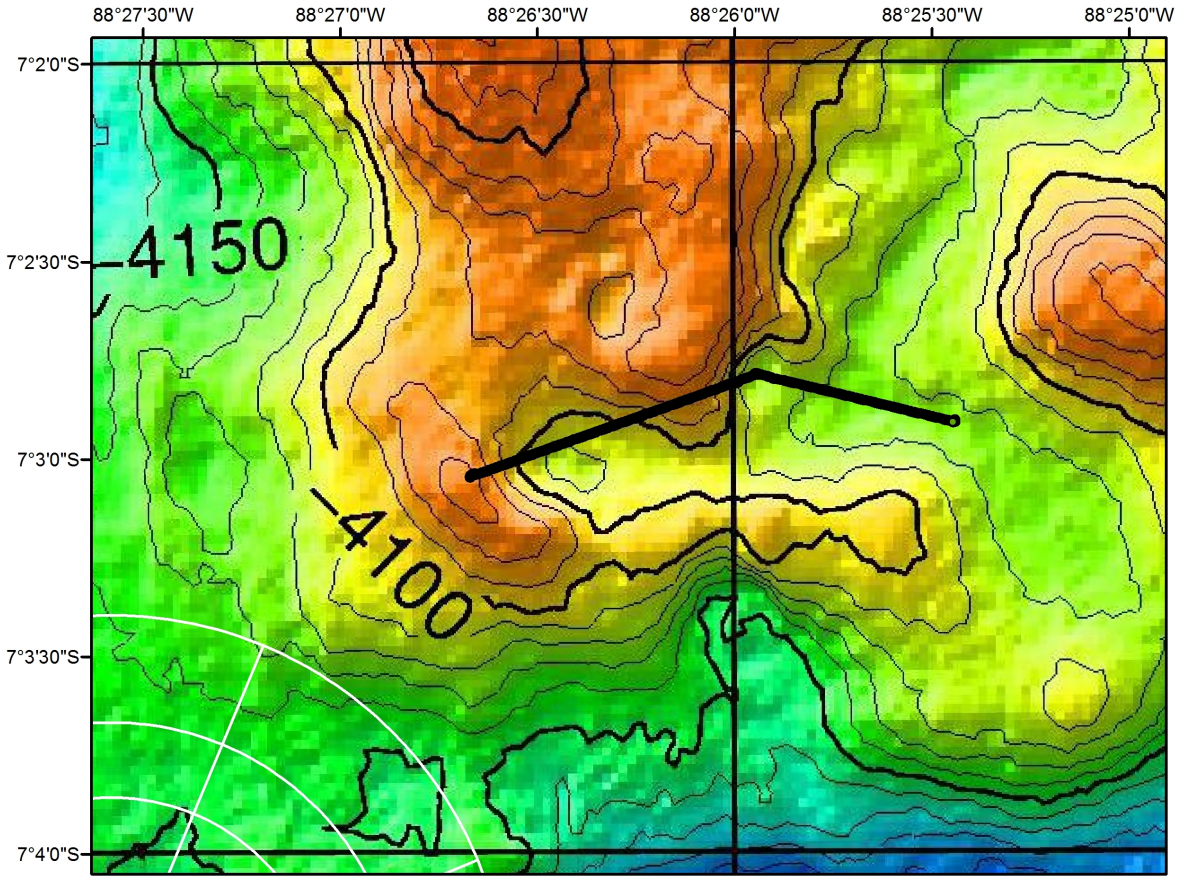
Navigation processing: Navigation was processed using OFOP smooth and spline..

Objective & Resume:

The dive was developed in a roughed area north of the DEA. The objectives included characterization of seafloor types across variable bathymetric features and identification of megafaunal component. These features include seamounts, slopes, caldera-shaped formations and local elevations of interest. The OFOS data will support a comprehensive interpretation in terms of benthic habitats.

OFOS interpretation during recording included both identification of megafauna and geological features simultaneously.

Figure of dive transect 242-1_#135_OFOS-6



Selection of photographs from previous cruises for analysis of temporal variation of megafauna

Still photographs obtained during previous cruises to DISCOL using OFOS deployments were collected under either a systematic or selective mode. In the former, exposure was made as near as possible to the instant at which the forward grappling iron visible on the television monitor made contact with the seafloor. From time to time, extra photographs were made while in the systematic mode, so as to record rare or unusual megafaunal taxa that might otherwise have been missed. While no such reference is made on cruise reports SO077 and SO106, the log (DAT) files from each dive make reference to made whenever systematic image collection is taken. Sections where systematic images were collected were identified in the log files and annotated to serve as a basis for ecological surveys. One OFOS survey with OFOS position, from each of the previous cruises was selected (note that not in all previous OFOS dives its position was estimated and recorded). Each OFOS dive selected crossed the entire DEA area to further allow for geospatial comparison. The selected dives to begin with annotation were SO061_OFOS_03, SO064_OFOS_22, SO077_OFOS_27, SO0106_OFOS_35 (Fig. 8.1.5.2).

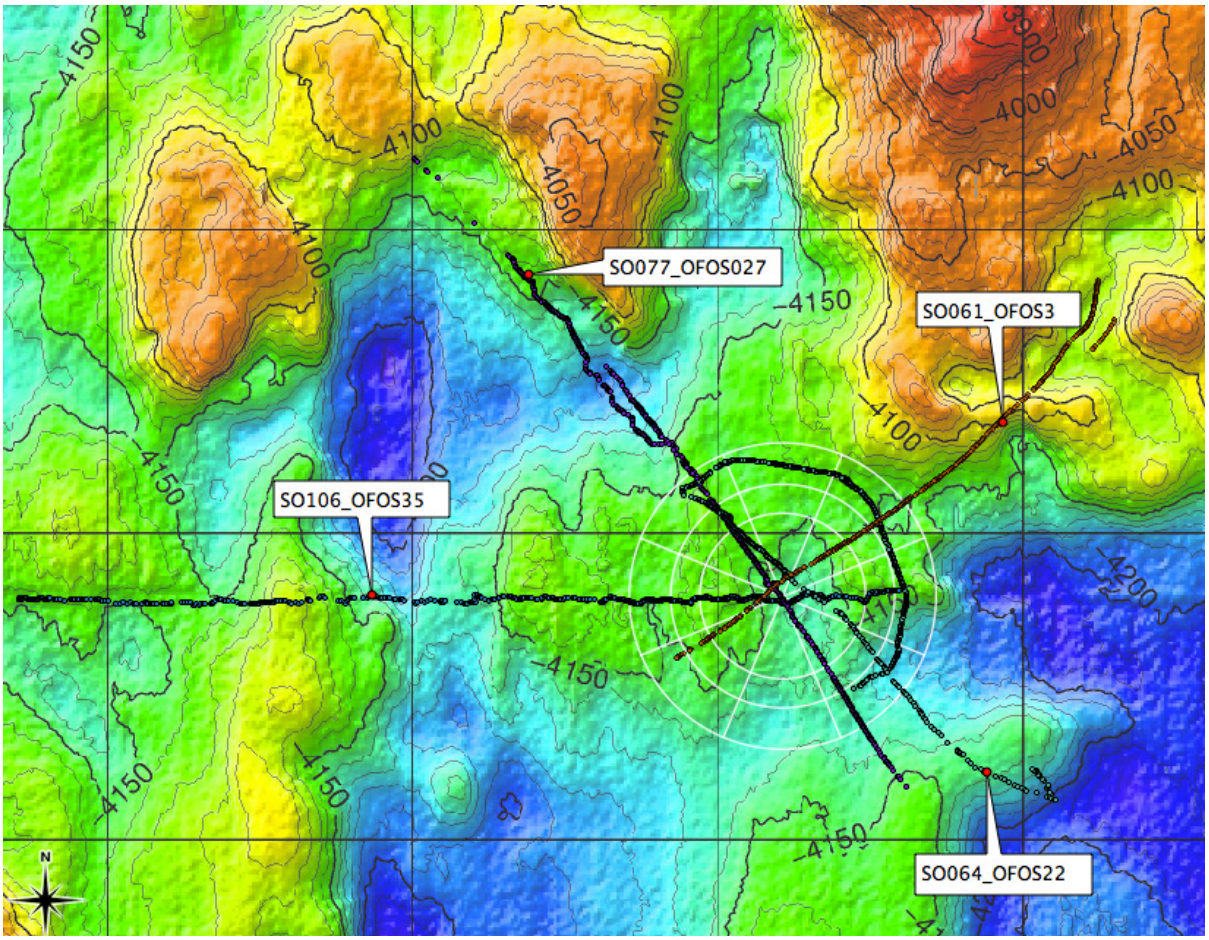


Figure 8.1.5.2: OFOS dives from previous cruises which images were annotated for temporal comparison.

8.2 Biological studies

8.2.1 Epi fauna

Nils Brenke

The C-EBS was deployed nine times during SO242/9, eight deployments were successful, only station EBS #104-6 failed as the sled flipped over and run upside down. Because of the towing distance between 600 m to 2000 m and consequently the comparable high number of sampled square meters not all EBS stations are closely related to the DEA area or the reference areas (Fig 8.2.1.1)

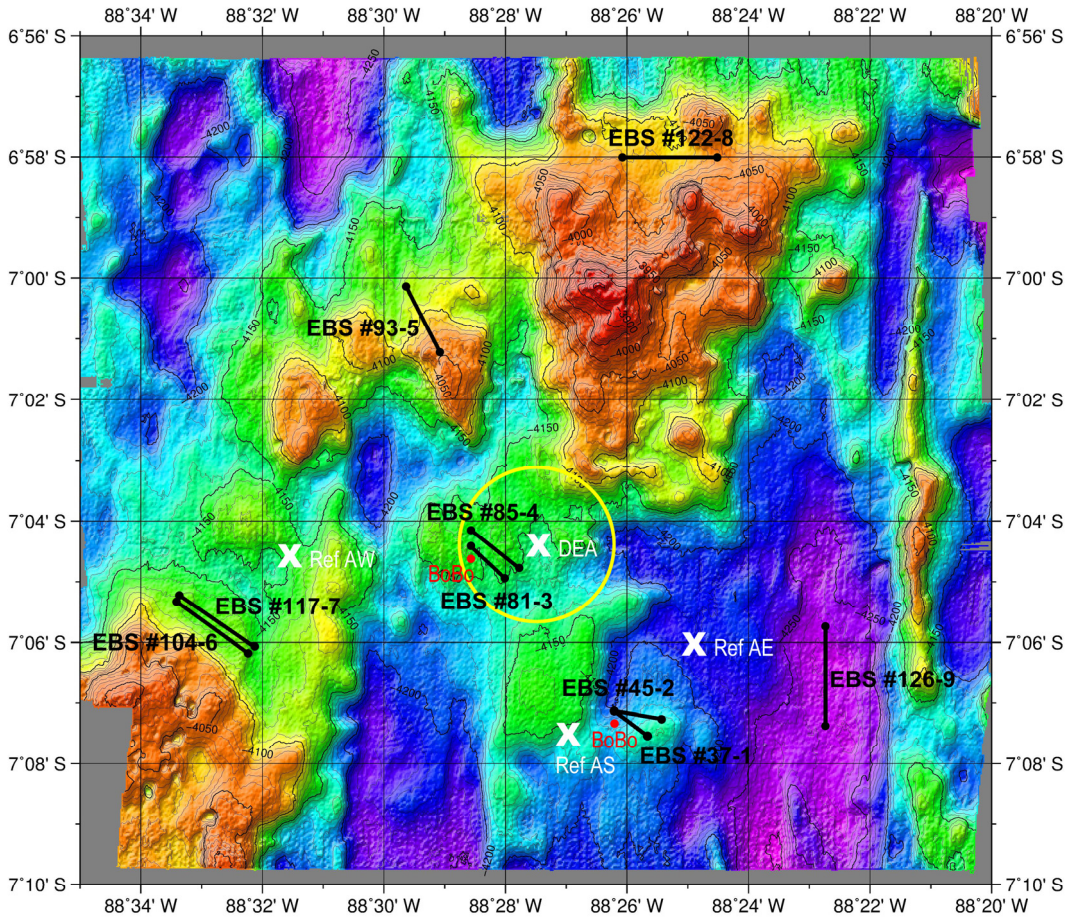


Fig. 8.2.1.1: Bathymetric map of the area around the DEA Area and the C-EBS deployments during DISCOL cruise SO242/1.

The EBS stations #81_EBS-3 and #85_EBS-4 are inside the DEA area in the south-western sectors. These two deployments as well as the EBS deployments #45_EBS-2 and #37_EBS -1 were used to accomplish disturbance experiments with the BoBo and DOS Lander (see chapter 8.5 EBS-disturbance experiments).The trawl distances were calculated according to the information from the tension meter and the wire length at EBS start haul and EBS off ground. The positions given in Table 8.2.1.1 are the ships position and not the EBS position on ground. Later, the calculation of the correct ground position of the sled, and consequently the exact trawl distances will be quantified using an USBL Posidonia positioning system. Figure 8.2.1.2.and 8.2.1.3 show the deep sea floor within the DEA with clearly visible plough-marks and undisturbed areas.

Tab. 8.2.1.1: List of all EBS hauls during the DISCOL expedition including the preliminary trawling distances for each haul.Furthermore, the mean value of the oxygen concentration and the mean value of the temperature at the bottom are shown, as well as the amount of usable pictures and minutes of video.

Discol 2015 SO242-1												
Sation	No.	Date	off Deck	Position Ship EBS on ground	Position Ship EBS off ground	depth	towing distance	O² Bottom	Temp Bottom	Pic. Still	Pic. CC	Video-CC
		UTC	UTC	Lat [°N] Lon [°W]	Lat [°N] Lon [°W]	[m]	[m]	[µM]	[°C]	[n]	[n]	[min]
# 37	EBS 1	03.08.2015	05:21	7°07.273'	7°07.752'	4190	603	138.485	1.828	1	101	166
				88°26.142'	88°25.587'							
# 45	EBS 2	04.08.2015	21:41	7°07.315'	7°07.935'	4183	717	138.611	1.829	53	50	122
				88°26.134'	88°25.354'							
# 81	EBS 3	13.08.2015	09:15	7°05.322'	7°05.757'	4157	1280	139.121	1.821	36	86	80
				88°28.004'	88°27.3677'							
# 85	EBS 4	14.08.2015	06:59	7°04.740'	7°05.293'	4147	1241	139.208	1.821	72	0	0
				88°28.136'	88°27.473'							
# 93	EBS 5	15.08.2015	13:48	7°00.954'	7°01.538'	4185	1563	139.599	1.820	0	109	96
				88°29.479'	88°28.799'							
# 104	EBS 6	17.08.2015	03:38	7°05.517'	7°06.511'	4140	1860	90.251	1.834	0	0	0
				88°33.194'	88°32.668'							
# 117	EBS 7	19.08.2015	22:36	7°06.105'	7°06.344'	4154	1745	138.275	1.818	0	0	0
				88°32.426'	88°32.161'							
# 122	EBS 8	20.08.2015	18:23	6°57.998'	6°58.020'	4080	2152	139.649	1.815	0	98	96
				88°25.312'	88°23.861'							
# 126	EBS 9	21.08.2015	11:15	7°06.328'	7°06.2344'	4257	1507	138.467	1.838	0	118	112
				88°22.798'	88°22.788'							

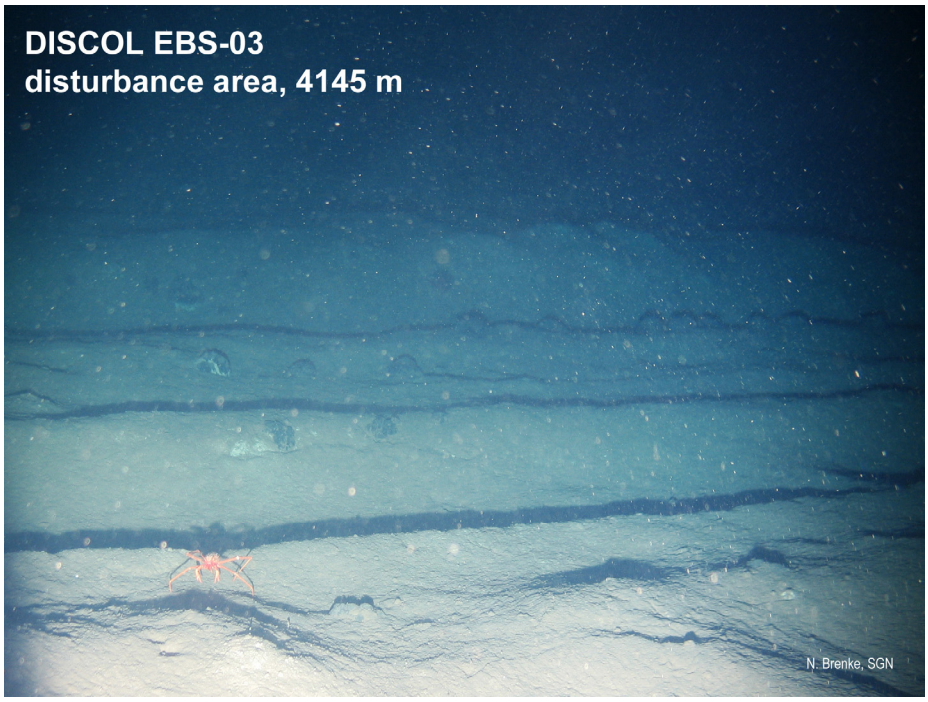


Fig. 8.2.1.2: The deep sea floor in 4145 meters depth in the southern part of the DEA with clearly visible plough-marks.

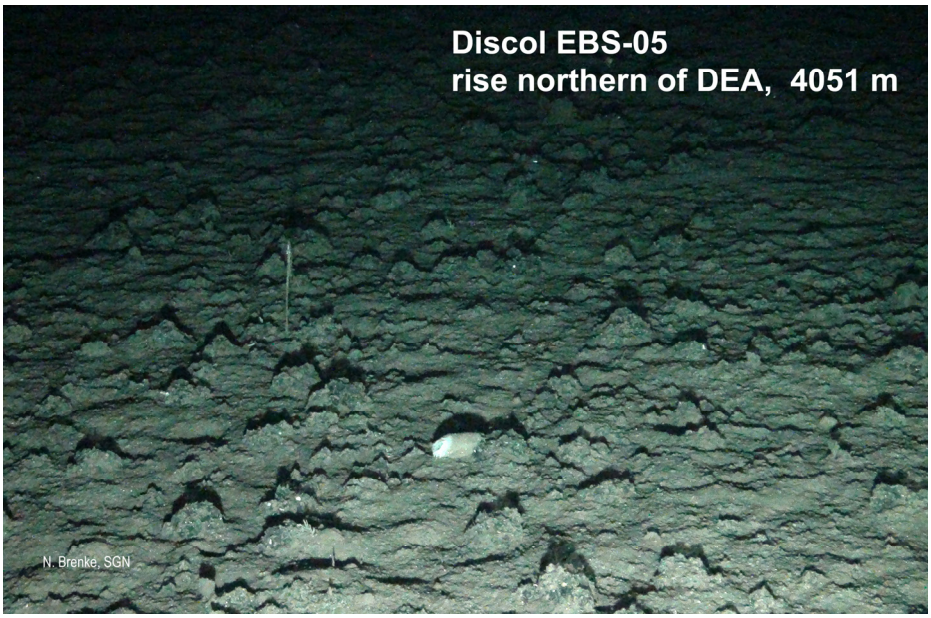


Fig. 8.2.1.3: The deep sea floor in 4051 meters depth with many nodules covered with marine snow.

8.2.1.1 Isopods(Sarah Schnurr)

For sample processing and molecular analyses of isopods the preparation procedure was as follows. The cod ends of the EBS were, when on deck, immediately removed and the samples were brought into a room with a temperature of 4°C. The samples were gently elutriated with precooled, filtered seawater and afterwards sieved through a 300 µm mesh sieve and immediately transferred into 96% pre-cooled un-denatured ethanol. A subsample of each cod end was taken beforehand and used for sorting of living specimens for approximately one hour. The remaining sediment as well as the specimens itself were fixed in 96% pre-cooled un-denatured ethanol after sorting and stored at -20°C. The nodule encrusting fauna was removed and also fixed in 96% pre-cooled un-denatured ethanol. The sediment samples were gently shaken every two hours within the first 12 hours of fixation to guarantee a thorough fixation of the whole sample. The ethanol was renewed after 24 hours. Further, the ethanol concentration was measured after 48 hours of fixation and samples were re-fixed again if the ethanol concentration dropped below 90%. The samples were kept cool throughout the entire time, in order to prevent tissue digestion (Riehl *et al.*, 2014).

The 163 isopod specimens present within the samples of the nine EBS deployments belonged to eleven isopod families (Figure 8.2.1.4). The family Munnopsidae was the most abundant one (72 individuals), followed by Desmosomatidae (33 individuals), Haploniscidae (25 individuals), Mesosignidae (10 individuals), Macrostylidae (9 individuals), Ischnomesidae (6 individuals), Dendrotionidae (2 individuals), Haplomunnidae (2 individuals), Anthuroidea (1 individual) and Bopyridae (1 individual).

One to three pereopods (depending on the size of the individual) of 158 isopod specimens were dissected and separately stored for tissue digestion and DNA amplification in 96 well plates, which were stored at a temperature of 0°C. The complete molecular investigations (DNA extraction, Polymerase Chain Reaction amplification and DNA sequencing) of the isopod data will be conducted at the Laboratories of Analytical Biology (LAB), Smithsonian Institution, Washington D.C.. The main focus will be on sequencing two gene loci: the cytochrome c oxidase subunit I (COI) and the ribosomal RNA large subunit (16S). This molecular approach on isopods aims to analyze the connectivity of isopods from the DISCOL area (SO242/1) and isopods from other regions as for instance the CCZ (SO239). Thus, Species delimitation methods as well as haplotype networks will be used to analyze the relationships of widely distributed species. Finally, the sequences will be

published in GenBank.Voucher specimens will be deposited after morphological investigations at the Zoological Museum of Hamburg.

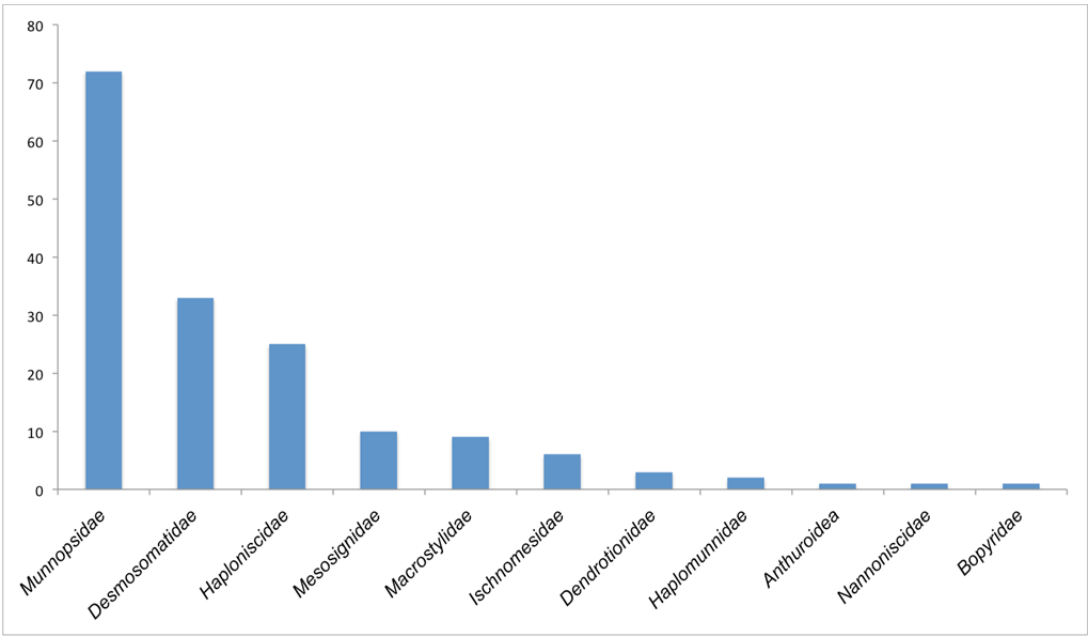


Figure 8.2.1.4: Number of individuals belonging to the different isopod families from all nine EBS deployments.

Tab. 1: Number of individuals belonging to the different isopod families at each station.

Station	*Munnopsidae*	*Desmosomatidae*	*Haploniscidae*	*Mesosignidae*	*Macrostylidae*	*Ischnomesidae*
#81	5	2			1	
#85	8	1	2		2	1
#45		5	1		2	
#37	3	2			3	1
#126	9	3				
#93	27	10	18	9		3
#122	16	8	2			1
#117	4	2	2	1	1	

Station	*Dendrotionidae*	*Anthuroidea*	*Nannoniscidae*	*Bopyridae*	*Haplomunnidae*
#81			1		
#85	1				
#45				1	
#37					1
#126	1				
#93					1
#122	1				
#117		1			

8.2.1.2 Polychaeta(Karin Meißner & Thomas Knebelsberger)

In samples from the epibenthic sledge Polychaeta predominated among macrofauna organisms. Altogether 427 specimens were collected. They belong to 36 supraspecific taxa. In comparison, the disturbed areas (DEA) were less densely populated than the different reference (undisturbed) areas, though it has to be considered that only two samples come from the DEA opposed to six samples

from the reference areas. The mean number of individuals per sample in the DEA was 37±7.1 (sd) belonging to 18 supraspecific taxa. In the reference areas 57.75±33.35 (sd) specimens were found in average belonging to 19.2±3.97 (sd) supraspecific taxa. The most speciose station was the Reference NW #93_5 with 24 taxa; the number of individuals at this station was 120.

station	#37_1 Reference South	#45_2	#81_3 DEA	#85_4	#93_5 Reference NW	#104_6 failed	#117_7 Reference SW	#122_8 Reference N	#126_9 Reference East	total
N specimens	48	33	32	42	120	2	30	70	50	**427**
taxa	21	14	18	18	24	1	19	22	15	**36**

The composition of the polychaete community was only slightly different between the DEA and the reference areas, but again the number of samples from each area has to be considered (only two from the DEA and six from the reference areas). The main difference is the higher proportion of rare taxa in the reference area due to the overall higher number of specimens (353 specimens opposed to 74) resulting in a higher number of supraspecific taxa in the reference areas (35 taxa opposed to 24). In all samples the Spionidae were the dominant group. Other important taxa were the Cirratulidae, Maldanidae, Syllidae, Pilargidae. In the DEA the Syllidae predominated the polychaete community with 17.6% whereas this taxon was subdominant (4.8%) in the reference areas as well as the Opheliidae and Polynoidae (Figure 8.2.1.5). The Lumbrineridae were well represented in the DEA but less numerous in the reference areas (Figure 8.2.1.6). Looking at the feeding habits of numerically important polychaetes it can be postulated that selective and non-selective deposit and substrate feeders are present as well as carnivores (predators) and omnivores.

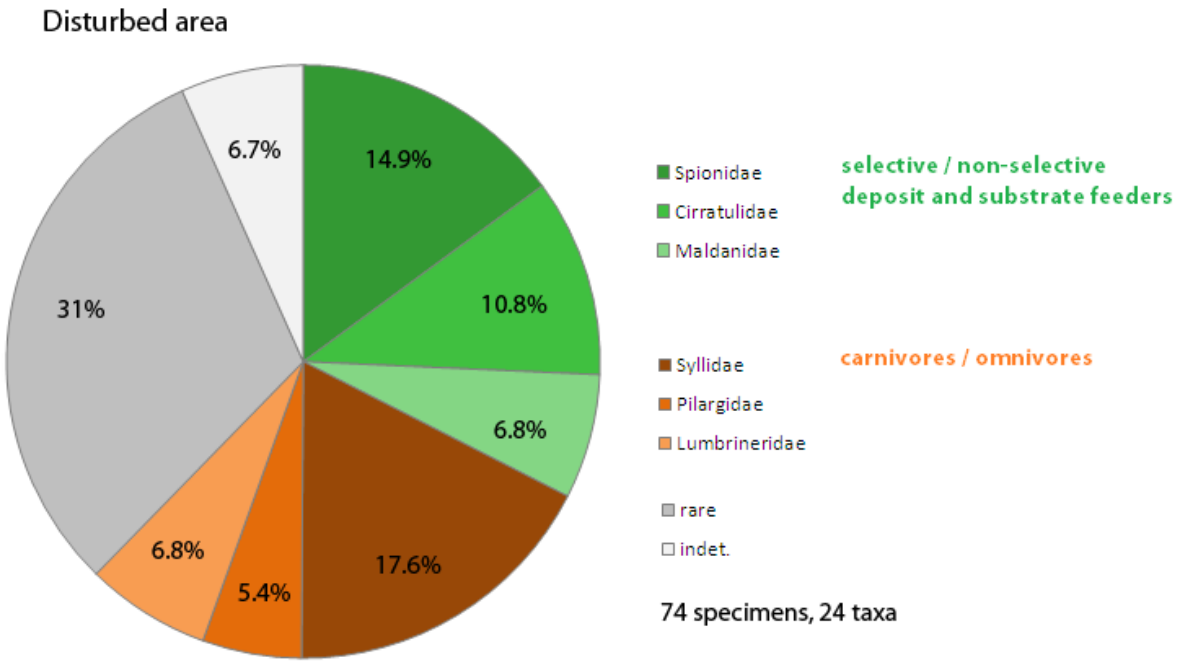


Figure 8.2.1.5: Fauna distribution of Polycheta inside the disturbed area (DAE)

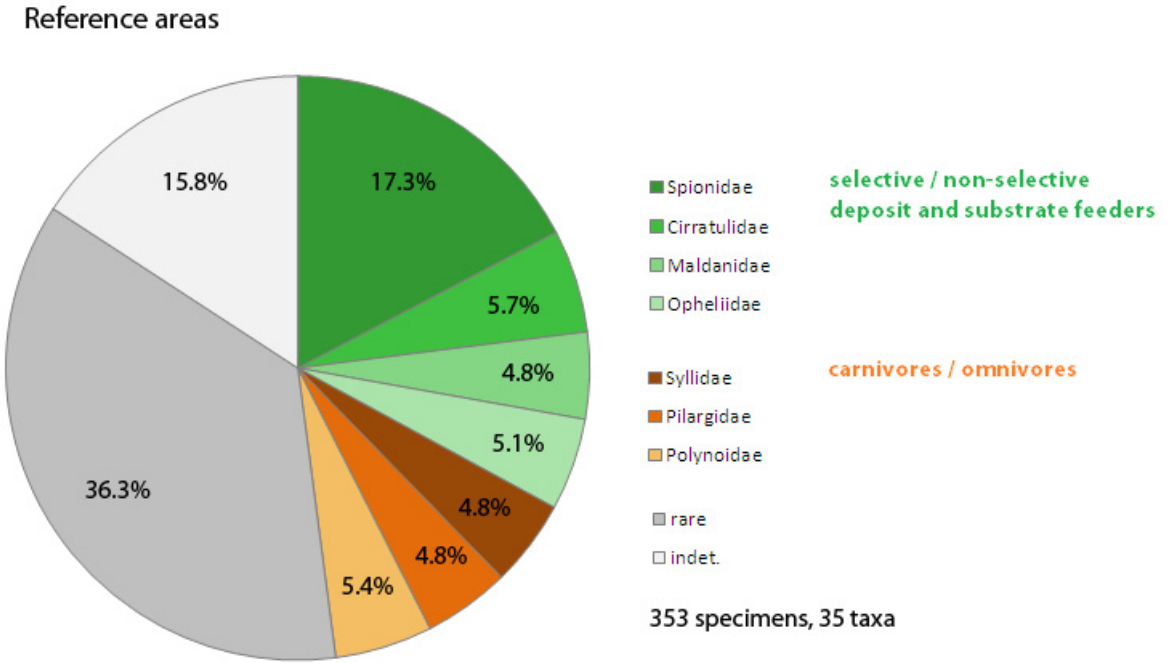


Figure 8.2.1.6: Fauna distribution of Polycheta outside the disturbed area.

Our results are in good agreement with former studies by Borowski& Thiel (1998) and Borowski (1996). The authors had published data on the composition of the polychaete communities sampled with a box corer in the DISCOL area shortly after disturbance, half a year and three years after disturbance. They distinguished between reference samples, and undisturbed samples and disturbed samples from the DEA. Their taxonomic analysis of polychaetes revealed 37 supraspecific taxa to occur in the DISCOL area. The taxon dominating in all areas after three years has been the Spionidaewith a percentage between 26.7-28.5%. Other numerically important groups were the Paraonidae, Cirratulidae, Opheliidae, Syllidae, Pilargidae. Except for the Paraonidae these are the taxa which are dominating elements of the polychaete communities at present. The Maldanidae (2.8%) and Lumbrineridae (4.8) are listed with elevated dominance ranks only for the disturbed samples and the Lumbrineridae (3.6%) in the undisturbed samples from the DEA by Borowski& Thiel (1989). In conclusion, we can postulate that the composition of the polychaete communities sampled with the EBS during SO242-1 are quite similar to the stage which was reached three years after disturbance documented by Borowski& Thiel (1989). The only notable difference is the decreased abundance of Paraonidae in our samples, which we cannot explain based on available information.

8.2.1.3 Molecularanalyses(Thomas Knebelsberger& Karin Meißner)

Out of the 427 polychaetes collected from the EBS samples a number of 300 specimens were fixed in 96% undenaturated ethanol for molecular investigations. One part of eachspecimen was placed in an 96-well formatted plate for semi-automated DNA isolation. The other part was kept as reference voucher specimen for further taxonomic investigations. The aim of the molecular part of this project is the establishment of a DNA sequence reference library, which can be used for molecular identification of poychaete specimens from the investigated area. It is planned to use the library for the analysis of polychaetes sampled with the box corer during SO242-1, in order to compare species occurrences between the different sampling sites.

At the DZMB in Wilhelmshaven ethanol preserved samples will be processed including DNA extraction, PCR amplification and DNA sequencing. For the establishment of the reference library a standardized region of the mitochondrial cytochrome c oxidase subunit I (COI) gene, the so called DNA barcode, will be amplified and sequenced. The DNA barcodes will be compared with sequences available from data repositories like GenBank or the „barcode of life datasystems“ (BOLD) for further taxonomic annotation. For unidentified sequences „molecular operational taxonomic units“ (MOTU's) will be defined. After the setup of the library, polychaete specimens can be identified by analysing the DNA barcodes together with our library data. On a global scale, our data can be compared with already available DNA barcode sequences from polychaetes of other deep sea regions like the CCZ. Haplotype networks can be calculated in order to analysephylogeographic patterns between populations of widely distributed species.

8.2.2 Makro fauna

Clara Rodrigues &Patricia Esquete

The samples were obtained at four different sites, 14 cores were taken inside the DEA, 5 cores each were taken at the southern and western reference side and one core was taken in a small crater NE of the DEA (this one was not analyzed quantitatively). Once the box-corer was back on board, the water overlying the sediment sample was siphoned off through a 300-µm mesh sieve. A picture of the surface of the core was taken (see Annex 9.2). When present, the nodules were investigated and visible epifauna was removed, preserved in 96% ethanol and kept separately. Nodules were then removed and gently washed in cold sea water to remove most of the attached sediment. The water from the nodule washing was later added to the 0-3 cm fraction. The core was sliced into three layers (0-3 cm, 3-5 cm and 5-10 cm). Sediments from each layer were transferred into cold sea water and the three different layers were washed with current filtered seawater through a sieve column (500 and300-µm). The fraction of the surface water sieved was kept separately. All sieve residues were preserved in 96% un-denatured ethanol. The ethanol was changed after 24h and levels of ethanol were controlled 48h later. See Table 8.2.2.1 for complete list of samples.

In addition to the collection of the sediment for macrofaunal studies the shear strength was also measured (see Appendix 9.3) and one small spoon of sediment was collected at surface and at 10 cm for granulometric analysis (NIOZ). The rest of the sediment present in the box-corer was verified for the presence of nodules. All the nodules were measured and weighted. After the cruise, the animals will be sorted under a stereomicroscope and deposited in the Biological Research Collection of Universidade de Aveiro where they will be available for further ecologic, taxonomic, morphologic and genetic studies.

Table 8.2.2.1: Stations detail in each working area and total number of samples recovered for macrofaunal studies. Area: SRS, Southern Reference Side, WRS, Western Reference Side.

Station	BC nº	Area	Sample distribution
St242_1_20	BC1	SRS	Total of samples recovered 7, UAveiro
St242_1_26	BC2	SRS	Total of samples recovered 6, UAveiro
St242_1_27	BC3	SRS	Total of samples recovered 8, UAveiro
St242_1_31	BC4	SRS	Total of samples recovered 8, UAveiro
St242_1_32	BC5	SRS	Total of samples recovered 9, UAveiro
St242_1_48	BC6	DEA	Total of samples recovered 7, UAveiro

St242_1_49	BC7	DEA	Total of samples recovered 7, UAveiro
St242_1_52	BC8	DEA	Total of samples recovered 7, UAveiro
St242_1_53	BC9	DEA	Total of samples recovered 7, UAveiro
St242_1_54	BC10	DEA	Total of samples recovered 8, UAveiro
St242_1_77	BC11	WRS	Total of samples recovered 8, UAveiro
St242_1_78	BC12	WRS	Total of samples recovered 8, UAveiro
St242_1_86	BC13	WRS	Total of samples recovered 8, UAveiro
St242_1_87	BC14	WRS	Total of samples recovered 8, UAveiro
St242_1_95	BC15	WRS	Total of samples recovered 8, UAveiro
St242_1_96	BC16	DEA	Total of samples recovered 8, UAveiro
St242_1_98	BC17	DEA	Total of samples recovered 8, UAveiro
St242_1_101	BC18	DEA	Total of samples recovered 7, UAveiro
St242_1_103	BC19	DEA	Total of samples recovered 9, UAveiro
St242_1_105	BC20	DEA	Total of samples recovered 8, UAveiro
St242_1_120	BC21	DEA	Total of samples recovered 7, UAveiro
St242_1_121	BC22	FAILED	
St242_1_124	BC23	DEA	Total of samples recovered 7, UAveiro
St242_1_127	BC24	DEA	Total of samples recovered 7, UAveiro
St242_1_128	BC25	DEA	Total of samples recovered 7, UAveiro
St242_1_129	BC26	NE of DEA	Total of samples recovered 4, UAveiro

8.2.3 Meio fauna

During SO242/1 no analyses have been performed with regards to meio fauna studies. See chapter 7.7 for sample distribution of MUC liners for faunal studies and involved people.

8.2.4 Scavengers (Amphipods et al.)

Henri Robert, Tasnim Patel&José Nuno Gomes-Pereira

Amphi-Trap deployments

The baited trap was deployed in 5 distinct localities. Our aim was to obtain samples from within the DEA to compare with other samples from 2 stations approximately 10 km away and 2 other stations approximately 40 km away, respectively in an area with nodules and another one without nodules. Amphipods are scavengers with strong chemo-receptors. Therefore, to more accurately assess their dispersal capabilities these sampling distances were chosen. Figure 8.2.4.1 shows a map of the 5 deployments. Details of the deployments are listed in Table 8.2.4.1.

Sample processing

Subsequent to the recovery of the amphi-trap, all attached traps are disconnected and placed in pre-cooled (4°C) buckets of filtered seawater. These are then placed in a cool climate laboratory (4°C) and all specimens are carefully washed using filtered seawater pisettes. Samples are then fixed in pre-cooled ethanol (-20°C) and sorted by morphotypes (Figure 8.2.4.2). Prior to shipment, all levels of ethanol were checked using a density probe and refixed with fresh ethanol if levels were below 90%.

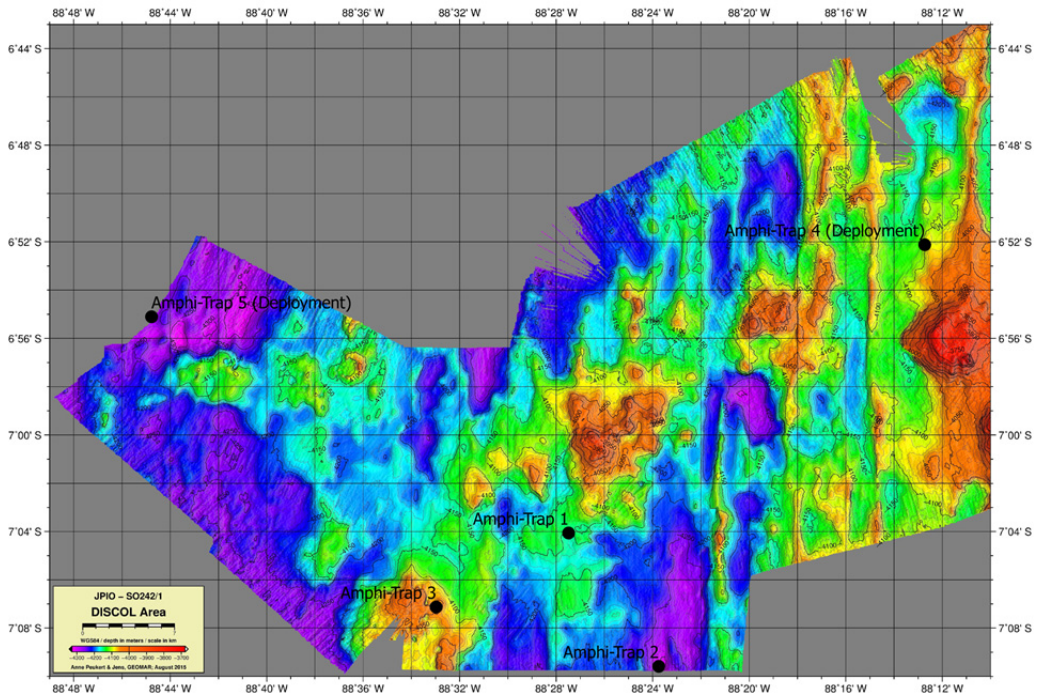


Figure 8.2.4.1: Bathymetric map showing the location of the 5 Amphi-Trap deployments. (map Anne Peukert)

Figure 8.2.4.2: Image showing Henri Robert and Tasnim Patel during the sample processing phase in the cool climate lab. Image by: Patricia Esquete Garrote

Table 8.2.4.1: A summary of the 5 baited trap deployments

Comment (Device Operation)	Station - Device Operation	Date/Time (UTC)	Action	Gross Deployment Duration	Net Deployment Duration (minus approx. gear transit time)	Ship (Lat/Lon)		Device (Lat/Lon)		Comment (Action)	Approx. Area	Exact distance from DEA (km)	Water Depth (m)
Amphi-Trap 1	242-1_8-1	2015/07/30 17:02:36.000	Deployment	47:26:33	44:26:33	-7:04.066	-88:27.487	-7:04.066	-88:27.487	-	DEA Actual	0.672 km from centre of DEA Actual	4145.7
Amphi-Trap 1	242-1_8-1	2015/08/01 16:29:09.000	Recovery	47:26:33	44:26:33	-7:04.174	-88:27.894	-	-	-	DEA Actual	0.672 km from centre of DEA Actual	4144
Amphi-Trap 2	242-1_30-1	2015/08/02 11:02:20.000	Deployment	54:11:18	51:11:18	-7:09.387	-88:23.610	-7:09.588	-88:23.749	-	10km away from DEA (low area)	12.0 km south	4307.4
Amphi-Trap 2	242-1_30-1	2015/08/04 17:13:38.000	Recovery	54:11:18	51:11:18	-7:09.722	-88:24.061	-	-	-	10km away from DEA (low area)	12.0 km south	4269
Amphi-Trap 3	242-1_55-1	2015/08/06 11:33:10.000	Deployment	28:09:09	25:09:09	-7:07.129	-88:32.962	-7:07.131	-88:32.977	-	10km away (high area)	11.1 km south-west	4043.3
Amphi-Trap 3	242-1_55-1	2015/08/07 15:32:19.000	Recovery	28:09:09	25:09:09	-7:07.475	-88:33.323	-	-	-	10km away (high area)	11.1 km south-west	4089.5
Amphi-Trap 4	242-1_68-1	2015/08/11 07:39:46.000	Deployment	68:20:46	65:20:46	-6:52.128	-88:12.723	-	-	no Posidonia signal	40km away from DEA (high area)	35.7 km north-east	4077.6
Amphi-Trap 4	242-1_68-1	2015/08/14 04:00:22.000	Recovery	68:20:46	65:20:46	-6:52.296	-88:13.199	-	-	-	40km away from DEA (high area)	35.7 km north-east	4117.9
Amphi-Trap 5	242-1_106-1	2015/08/17 18:19:50.000	Deployment	50:00:50	47:00:50	-6:55.112	-88:44.776	-	-	no Posidonia signal	40km away from DEA (low area)	36.0 km north-west	4268.7
Amphi-Trap 5	242-1_106-1	2015/08/19 20:19:55.000	Recovery	50:00:50	47:00:50	-6:54.725	-88:44.859	-	-	-	40km away from DEA (low area)	36.0 km north-west	4237.1

Amphipods

Preliminary sorting onboard has yielded many different species as well as a large size range of Amphipoda *(fig. 5)*. In addition, there are several different morphotypes. The most distinctive are the crested and non-crested Eurythenes species (Figure 8.2.4.3). These have also been found in the CCZ but it remains to be analysed whether these morphotypes are also the the same genotypes. A full list of morphotypes sorted on board can be found in Appendix 9.7.

Figure 8.2.4.3: left Image showing the variety of sizes of amphipods obtained during this cruise. top right crested middle right non-crested Eurythenes sp. bottom right close-up of telson on the non-crested Eurythenes. Images by: Tasnim Patel & Henri Robert

Zoarcidae by catch in Amphipod traps

Several Zoarcidae fishes where caught as bycatch in Amphipod traps in the Peru Basin, during the DISCOL cruise SO242-1 (Table 8.2.4.2). A total of 12 specimens were collected from four Amphipod trap deployments between 4013 and 4265m depth. The specimens entered the trap and arrived the surface inside the traps with stomachs full of amphipods. These were collected and cleaned for later taxonomic analyses by Tasnim Patel. The fish specimens range from 33.6 to 50.6 cm (SL) and present similar meristics (Tabel 8.2.4.3), including a light brown/grey coloration, elongated body without scales (body depth at origin of anal fin 9.6-15% SL), dorsal, caudal and anal fins fused. By the absence of pelvic fins and pores on the heads, it has lead to a preliminary identification within the

Zoarcidaefamily. Further meristics and molecular analysis will allow me to validate species identification and support connectivity studies.

The specimens were collected by Henri Robert and TasnimPatel. The specimen meristics and general preliminary description was developed by José Gomes Pereira from MARE-IMAR-DOP, University of the Azores. Muscle samples and fin tissue samples were collected from the fresh animals and kept in ethanol 96%. Each fish was kept in a separate jar with 70% ethanol. Stomach contents were removed from specimens #2-5 from station St68 and specimens #10-12 from station #106. No fish was weighted on board.

Table 8.2.4.2: Table showing fish samples collected during 48h amphipod bait trap deployments in SO242-1; All specimens were kept in ethanol 70% and DNA samples in ethanol 70%.

Station	Date	Total sp	SpNum#.	Depth (m)	Lat	Lon	Jars/ Specimen	DNA samples
#08	30 Jul - 1 Aug 2015	2	#2-3	4150	-7.067766667	-88.45811667	2/2	4
#30	04-06 Aug 2015	1	#1	-	-7.156383333	-88.45811667	1/1	2
#55	06-08 Aug 2015	0	0	4013	-7.118766667	-88.54963333	-	-
#68	11-13 Aug 2015	6	#4-9	4083,8	-6.8686	-88.21211667	6/6	12
#106	17-19 Aug 2015	3	#10-12	4264,7	-6.918533333	-88.79631667	3/3	3

Elongate body. Dorsal and anal fins long and continuous with caudal and anal fin. Pelvic fins absent, without scales. No pelvic fins, no scales in head. Pectoral fins rounded and not elongated. The dorsal insertion anterior than anal.Several cutaneous pores on the head. Further small pores visible in large specimens. Prominent skin flap above opercle.Skin firm, brown to light brown and pale grey. No swimbladder. Teeth on vomer absent. Body depth at origin of dorsal fin might not be very useful as most specimens had enlarged stomachs full of amphipods. Stomachs were removed from several specimens and kept separate for posterior identification. Specimens were photographed fresh (Figure 8.2.4.4&5).

Figure 8.2.4.4: Illustrative images of specimens of Zoarcidae collected during cruise SO242/1 (top) from base to top, specimens #4-9 from station #68.

The difficulty in identifying these species stems from their strong morphological resemblance to one another, by the small number of distinguishing characteristics, and by the substantial morphological variations that exist within a species and that depends on the sex and age of individuals. The identification difficulty is supported by the lack of available bibliographic data on the organisms tied to the rarity of catching them.

Figure 8.2.4.5: Top image: from base to top specimens #10-12 from station #106; lower image: detail of some of the head pores of specimen #10.

Summary and next steps

We have collected a total of **37,665** specimens during SO242-1. In addition, we have observed several species in the DEA which were not found in the CCZ and vice versa. Mapping the taxonomic differences will enable us to comment on whether the disturbance type/intensity or habitat type/regional processes have any bearing on the the deep-sea taxa. The primary purpose of our

investigation is to elucidate how spatial scales influence species composition, dispersal patterns and connectivity. Some of the other questions we are trying to answer is whether there is a high regional diversity in this area and whether reduced gene flow over long distances limits the taxonomic connectivity. In sum, we would like to see how unique the fauna is to the DISCOL and CCZ areas and how this affects the community's post-impact recovery potential.

In addition to our primary sampling equipment, we also obtained samples from other groups using the Epibenthic Sledge (EBS) and Multi-Corer (MUC) gear. These, in additon to the bulk small amphipod samples will be sorted at RBINS by Tasnim Patel between August and December 2015. Prelimary identifications will be attempted under the supervision of Cédric D'udekem D'acoz and allow her to comment on the differences between nodule fauna, non-nodule fauna and seamount fauna.

In 2016 the aim is to focus on genetic analyses. This will enable an integrative taxonomic approach by combining molecular and morphological analyses. Using a model species (yet to be confirmed), DNA will be extracted using a Qiagen kit and the protocol outlined in Havermans *et al.* 2013. The extracted DNA will undergo Polymerase Chain Reaction (PCR) amplification of the mitochondrial (COI) gene and submarine agarose gel electrophoresis.

Subsequent to this, automated, direct Sanger sequencing in both directions using the Molecular Systematics Lab at RBINS will yield genetic sequences, which will then be edited and used to create phylogenetic trees for a population comparison and cryptic species detection between the CCZ and DEA. Ultimately, we would also like to compare the recently acquired samples with the older DISCOL samples from 1989. This will provide a baseline for taxonomic comparison and allow us to comment on the recolonisation potential of these species post-disturbance. The aims for the Zoarcidae fish is that the data analysis should proceed with molecular work coordinated by Thomas Knebelsberger who will conduct detailed meristics at Senckenberg University.

*Table 8.2.4.3:*The meristics of Zoarcidae fish caught during cruise SO242/1.

SO242/1	**#55**	**#08**		**#68**						**#106**		
# Number	1	2	3	4	5	6	7	8	9	10	11	12
Specimen Station/number	St55_1	St08_1	St08_2	St68_1	St68_2	St68_3	St68_4	St68_5	St68_6/B1			
Standard length		37	31.2	36.6	41	41.8	50.6	58.3	33.6	37.8	33.4	30.1
Dorsal finrays	-	-	-	-	-	-	-	-	-	-	-	-
Caudalfinrays	-	-	-	-	-	-	-	-	-	-	-	-
Anal finrays	-	-	-	-	-	-	-	-	-	-	-	-
Pectoralfinrays	-	18-22	14	-	-	-	-	-	-	19	17	17
Pelvicfinrays	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Teeth on vomer	-	-	-	-	-	-	-	-	-	no	no	no
Head length		4.9	4.1	4.9	5.6	5.3	5.9	6.6	6.7	5.7	4.8	4.2
Depth at origin of anal fin		4.6	3.0	5.5	4.3	4.4	6.1	6.9	4.9	5.4	4	3.8
Depth at origin of dorsal fin		5.5	3.6	6.5	5.4	5.1	6.8	8.2	5.6	6.4	5.4	4.6
Upperjawlength		1.2	1.2	1.1	1.1	1.3	1.6	1.9	1.7	1.6	1.3	1.2
Interorbital length		1.7	0.9	1.6	0.9	1.35	1.4	1.9	2.1	1.7	1.2	1.3
Postorbital length		3	2.5	3.4	3.2	3.3	3.7	4.2	3.7	3.4	3	2.7
Diameter ofeyewindow[A]		8.5	5.0	0.8	0.7	0.6	0.8	1	0.9	0.8	0.7	0.6
Preanallength		15.4	11.1	14.2	15.1	15.3	17.7	22.2	14.6	16.2	14.1	12.6
Predorsallength		7.4	5.1	7.6	7.8	7.7	8.8	9.3	7.7	8.1	6.4	6.2

[A] Until operculum insertion

8.3 Sediment geochemical studies

M. Haeckel, M. Dibbern, G. Schüssler, J. Drescher, S. Paul, I. Preuss, T. J. Suhrhoff

The geochemical analyses of the porewaters and sediments of the DISCOL area in the Peru Basin aim at quantifying the biogeochemical fluxes and turnover rates associated with organic carbon mineralization and polymetallic nodule formation. The goal is to identify and assess the impact of the disturbance and recolonization experiment set in 1989 by ploughing the seafloor. Sediment was cored by MUC, GC, and BC deployments at (a) 3 reference sites outside the DEA (all having nodules at the seafloor, but in varying abundances), (b) inside and next to the plough marks in the DEA, (c) in the bathymetric trough of the DEA, (d) a site in the DEA showing no nodules at the sediment surface (low backscatter intensity in the sidescan sonar image), and (e) a site with a high density of small nodules in the crater of a small volcano north-east of the DEA (Table 7.16.2 and Figs. 8.3.1 & 8.3.2). Overall, a comprehensive geochemical dataset will be collected from onboard and onshore analyses. A complete photo documentation and description of individual cores retrieved with MUC, GC, and BC can be found in Appendices 9.4 & 9.5.

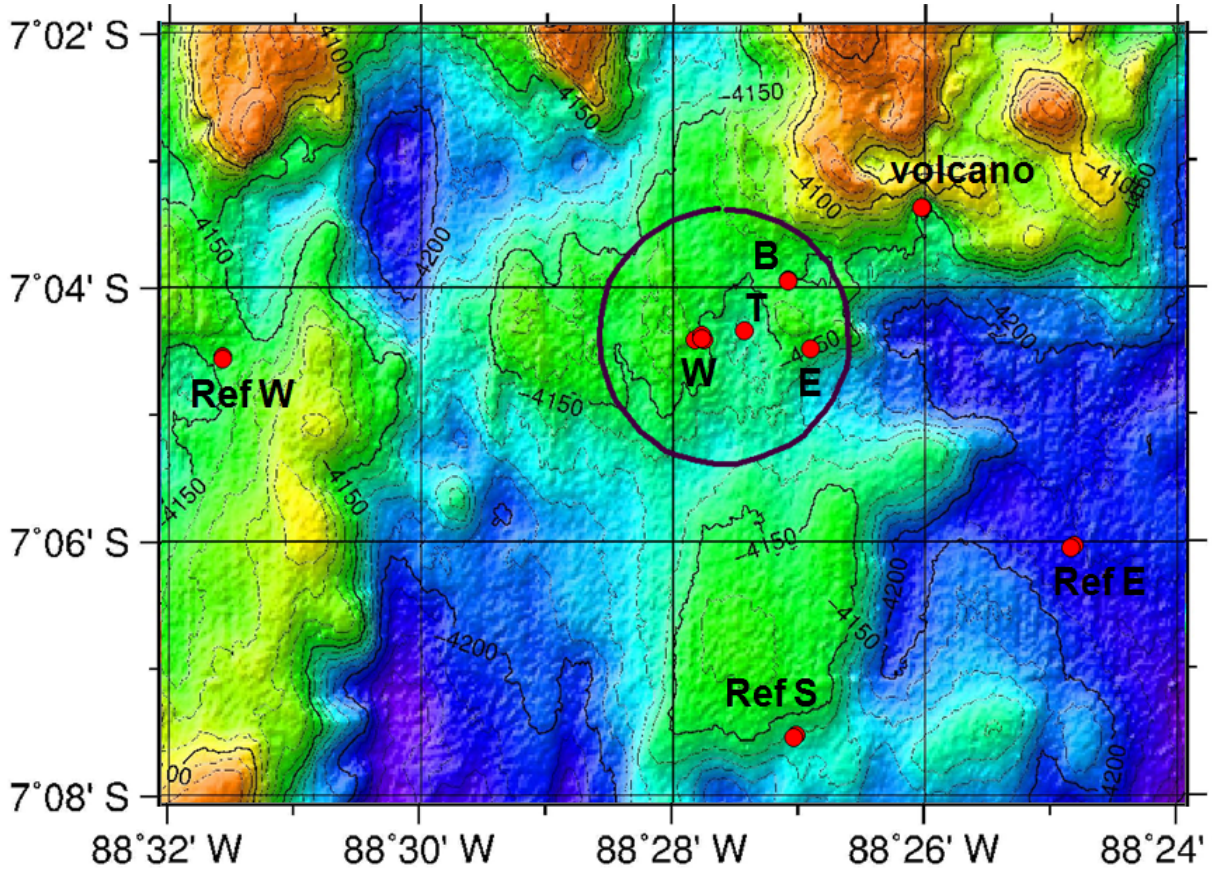


Figure 8.3.1: Overview map showing the locations of the different study sites

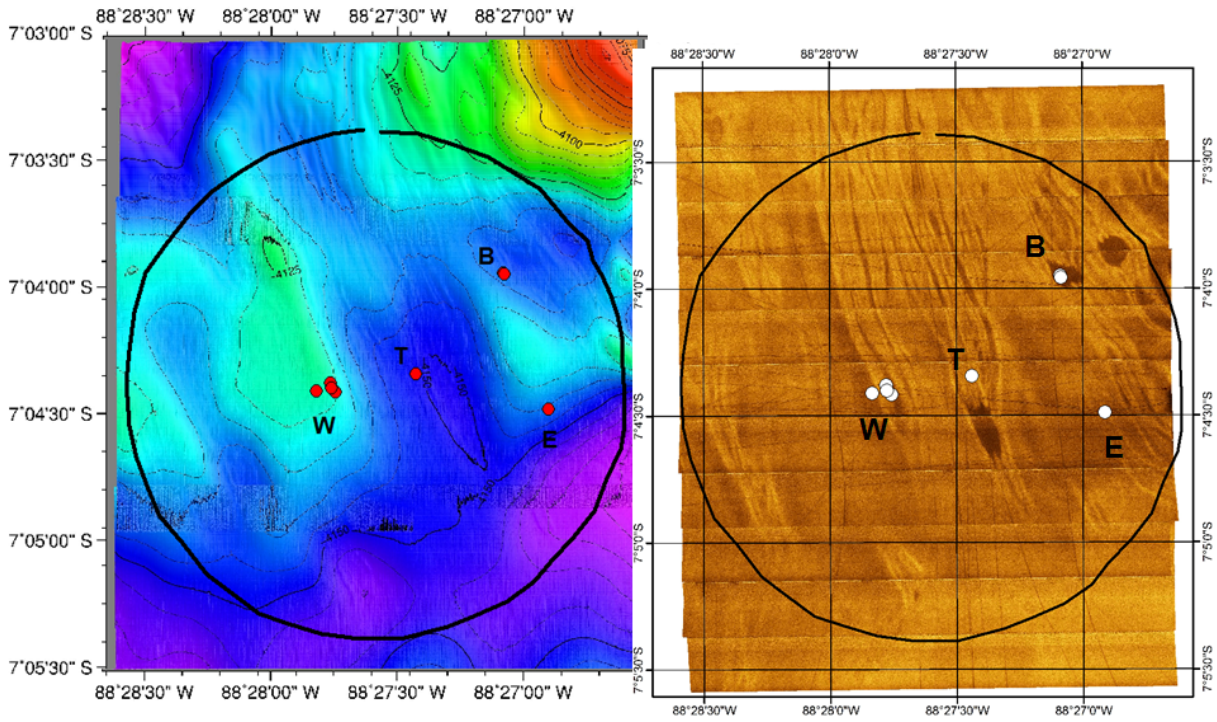


Figure 8.3.2: Bathymetric map and sidescan sonar image of the DEA showing the locations of the collected cores (W = western plough mark site, E = eastern plough mark site, T = trough site, B = site with low backscatter intensity in the sidescan sonar data). For coordinates see Table 7.16.2

During the former cruises in the DISCOL area only few cores were processed for sediment and porewater geochemistry. The general picture from those cores is that early diagenesis is governed by the low sedimentation rate (~0.4 cm/ka; Haeckel et al., 2001; Weber and Pisias, 1999) and resulting low organic carbon content (POC < 0.75 wt%; Haeckel et al., 2001). Compared to typical deep-sea environments this POC content is, nevertheless, higher, as the DISCOL area is located below the southern rim of the high productivity surface waters of the eastern equatorial Pacific. Consequently, organic matter degradation utilizes oxygen, nitrate, manganese(IV) and iron(III) oxides – sulfate reduction is not reached, at least in the upper meters of the sediment. Dissolved oxygen gets consumed in the upper 10-15 cm, as corroborated by the dark brown color of the sediment which arises from abundant manganese(IV)-oxyhydroxides. Here, nitrate concentrations peak with up to 40-60 µM. Further downcore NO_3^- decreases and gets depleted at 200-300 cm depth, whereas Mn^{2+} concentrations increase downcore to ~100 µM at 500 cm depth. Dissolved PO_4^{3-} and NH_4^+ in the porewater show rather low concentrations (< 10 µM) indicating little overall POC remineralization rates. Dissolved Fe^{2+} concentrations are also low, but a characteristic tan-green color change occurs in the sediment at the depth of NO_3^- depletion. This color transition is caused by the redox change of Fe(III)-to-Fe(II) bound in the clay minerals and is known to be related to nitrate consumption (Lyle, 1983). In the Peru Basin this iron redox transition has been quantified by Mössbauer spectroscopy, which showed that it is associated primarily to the clay mineral chlorite (Drodt et al., 1997; König et al., 1997; König et al., 1999; Lougear et al., 2000; Lougear et al., 2001).In the following sections preliminary results are discussed against these previous findings.

Shallow surface sediments at reference and DEA sites

Oxygen consumption increases from west to east in the DISCOL area, i.e. O_2 penetration depths vary by about 10 cm (Figure 8.3.3): in the western reference site O_2 penetration depth is not reached in the top 22 cm of the sediment, while it penetrates ~20 cm deep at the southern reference site, whereas it reaches down ~15 cm in the DEA and ~12 cm at the eastern reference site. In contrast, the other onboard measured porewater species do not show significant differences across those sites (Figure 8.3.4). The most sensitive variables discriminating disturbed from undisturbed sites and the reference situation are oxygen and nitrite. While O_2 exhibits a linear profile shape (at least partly) in the disturbed sediments of the plough marks compared to normal curved shapes at the reference sites (Figure 8.3.3), the zone where nitrite is elevated in the surface sediments is only 2-3 cm in the plough marks compared to 4-7 cm in undisturbed sediments (Figure 8.3.4). This pattern is interpreted as reduced bacterial activity in degrading organic carbon in the disturbed sediments of the plough marks compared to the undisturbed sites. Thus, the bacterial communities or ecosystem has not yet recovered or adapted to the disturbance even after 26 years.

Apparently however, diffusion has leveled out most of the disturbance created in the surface concentrations of the other measured parameters within 26 years, as their profile shape is controlled by diagenesis in the deeper strata and the Einstein-Smoluchowski relation predicts a diffusional length of ~100 cm for this period of time.

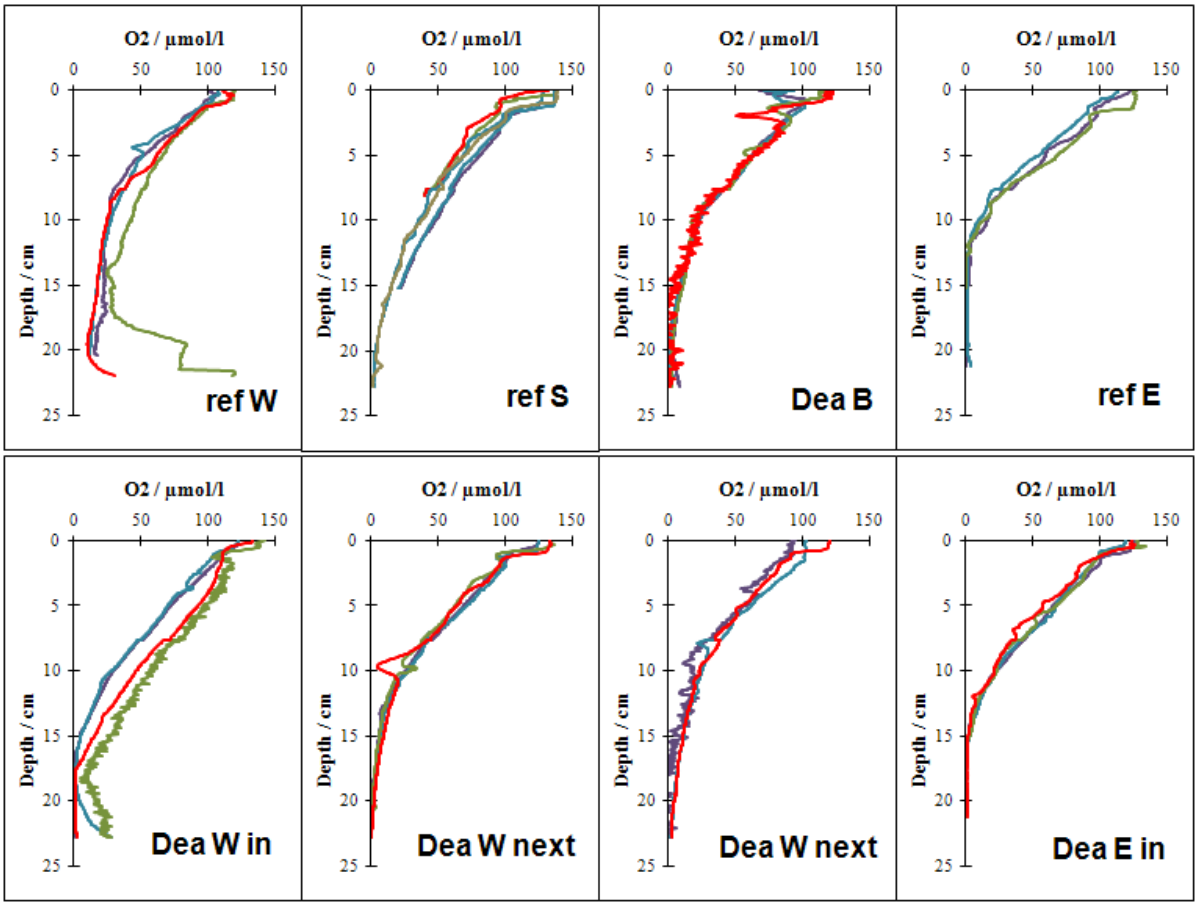


Figure 8.3.3: Measured exsitu oxygen concentration microprofiles in MUCs retrieved from the western (W), southern (S), eastern (E) reference sites, the DEA site with low backscatter intensity in the sidescan sonar image (B) as well as the western and eastern disturbed DEA sites inside and right next to plough marks.

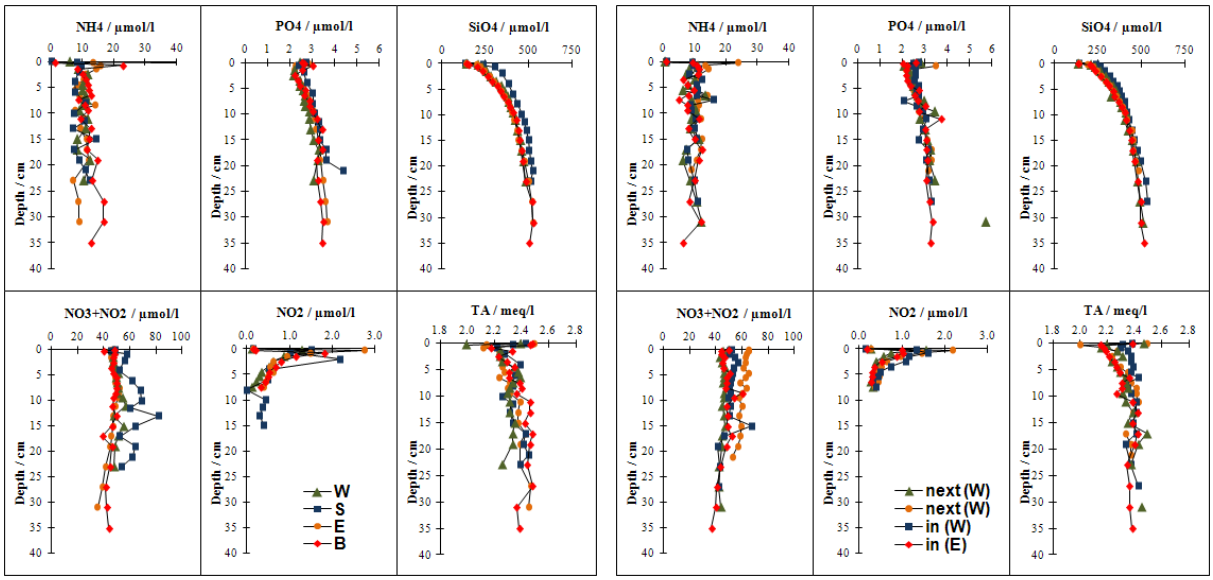


Figure 8.3.4: Measured concentrations of porewater constituents in MUCs from (left) the western (W), southern (S), eastern (E) reference sites, the area with low backscatter intensity in the sidescan sonar image (B) as well as (right) the western and eastern disturbed DEA sites inside and right next to plough marks.

Deeper sediment strata

In the deeper sediments (down to almost 10 m) the observed sediment sequences as well as the measured porewater nitrate concentration profiles exhibit much more variability and spatial heterogeneity (Figure 8.3.5) than in the shallow surface sediments. The tan-green colour change appears in varying intensities and sediment depths, but still correlates well with the NO_3^- penetration depth: in the DEA this redox boundary shoals from W to E from ~350 cm at the western disturbance site to ~250 cm at the eastern disturbance site and further to ~200 cm in the eastern reference site, while it is ~650 m at the southern reference site, and is completely absent at the western reference site and in the crater of the small volcano, where nitrate does not get depleted in the top 1000 cm of the sediment column.

The porewater nutrients, PO_4, NH_4, and SiO_4, and TA show only little regional variability: PO_4 concentrations decrease downcore by 2-3 µM, whereas NH_4 increases from 10 µM at the surface to 20-30 µM at the bottom of the cores, and TA increases slightly downcore from 2.4 meq/l to 2.6-2.7 meq/l, thereby reflecting POC degradation utilizing Mn(IV) and Fe(III). Silicate concentrations reach asymptotically ~650 µM and sometimes decrease slightly downcore again.

Several polymetallic nodules were found in deeper sediment strata of the GCs, exhibiting different degrees of decomposition and redox halos around them (see Appendix 9.4). The larger buried nodules are marked by star symbols in Figure 8.3.5. Stronger nodule weathering seems typically accompanied by decreases in TA, possibly explained by the redox reaction of MnO_2 with Fe(II) producing Mn^{2+} and $Fe(OH)_3$, which would consume bicarbonate and represent the source for dissolved manganese observed in the cores from SO106 (Haeckel et al., 2001).

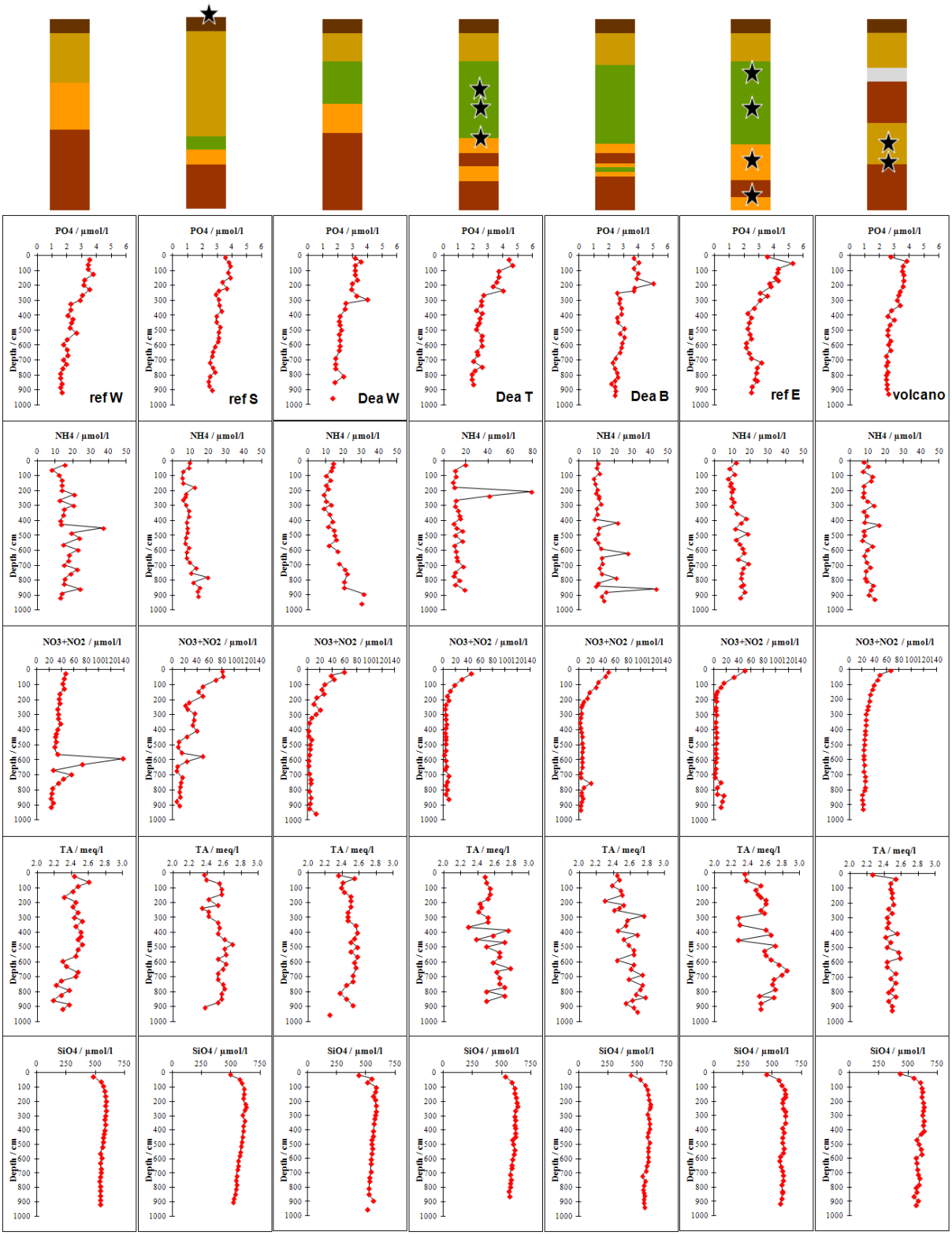


Figure 8.3.5: Measured concentrations of porewater constituents in the GCs at the western, southern, eastern reference sites and the DEA sites in the west, the trough, and the low backscatter area as well as in the crater of the small volcano. In the top row a simplified sequence of the observed sediment colors and nodule occurrences (stars) is sketched. For detailed core descriptions refer to Appendices 9.4 & 9.5.

8.4 Water column studies

8.4.1 CTD studies

Jens Greinert & Hannes Post

A total of 5 CTD casts were performed, two of them to acquire a sound velocity profile before seafloor mapping started at the beginning of the transit and in the DISCOL area (SO242/1_#1_CTD-1; #16_CTD-2). The data of the third CTD (#50_CTD-3) next to the Thermistor Mooring where unfortunately overwritten. This casts was planned to be re-done during SO242/2. Station #58_CTD-4 and #82_CTD-5 were inside the DEA, CTD-5 aimed of sampling the sediment plume generated by EBS station #81_EBS-3 in the western area of the DEA. Figure 8.4.1.1 shows some of the acquired data.

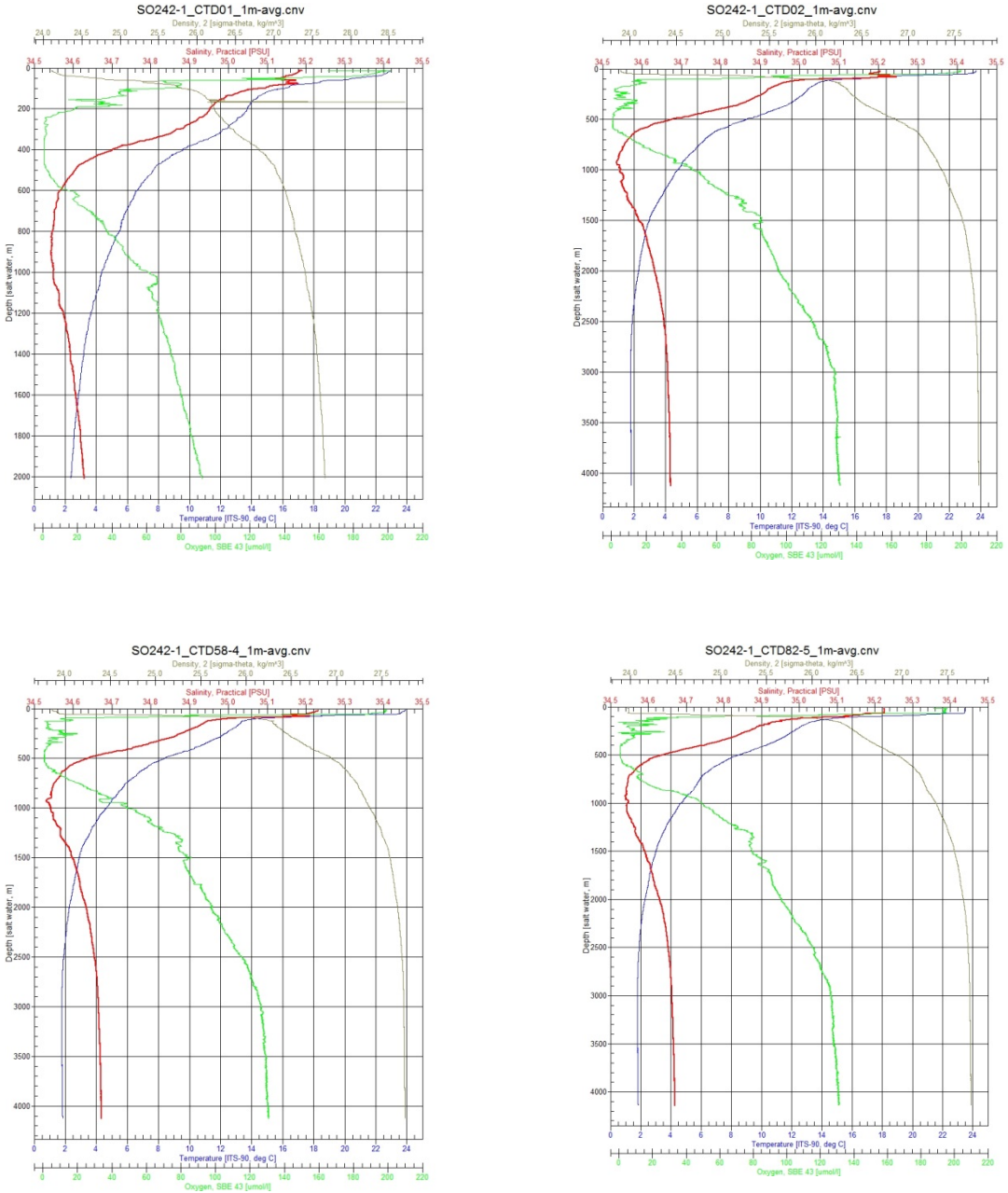


Figure 8.4.1.1: Physical and chemical data of the four CTDs undertaken during SO242/1.

8.4.2 MAPR studies

Cuiling Xu, Tim Weiß, Timm Schoening, Jens Greinert

The total of 76 deployments have been added to an ODV data base file for data examination. Figure 8.4.2.1 shows all temperature profiles over time of the top 500m of the water column. The temperature profiles are almost the same at the DEA area. The temperature of topmost 40 m water constant at about 24 °C, while sharply decreased to around 15 °C at 100 m depth. The bottom temperatures show a similar structure for all areas, pointing towards the same water mass (Figure 8.4.2.2). The temperatures of bottom water were about 1.8 °C to 1.85 °C, slightly increased with water depth.

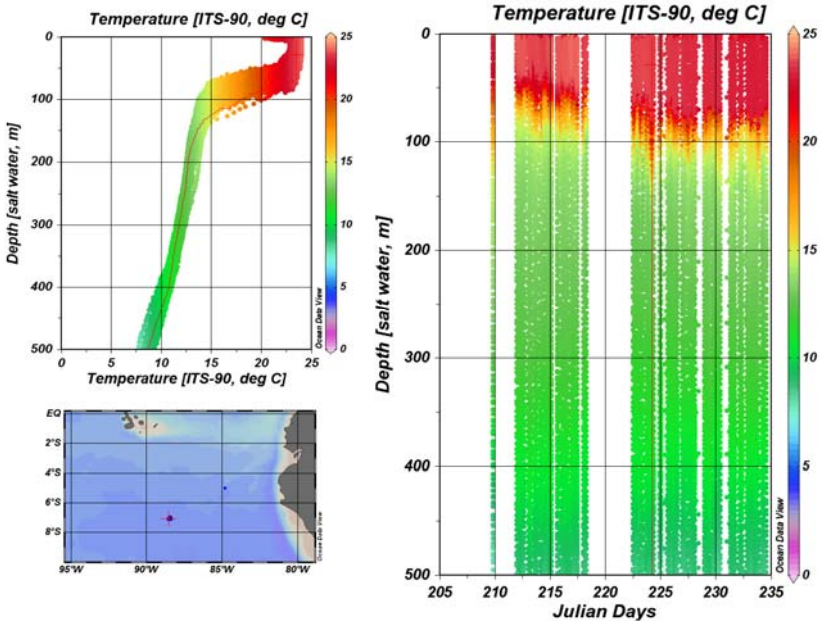


Figure 8.4.2.1: Sea surface temperatures of the working areas and a reference station at the northeast.

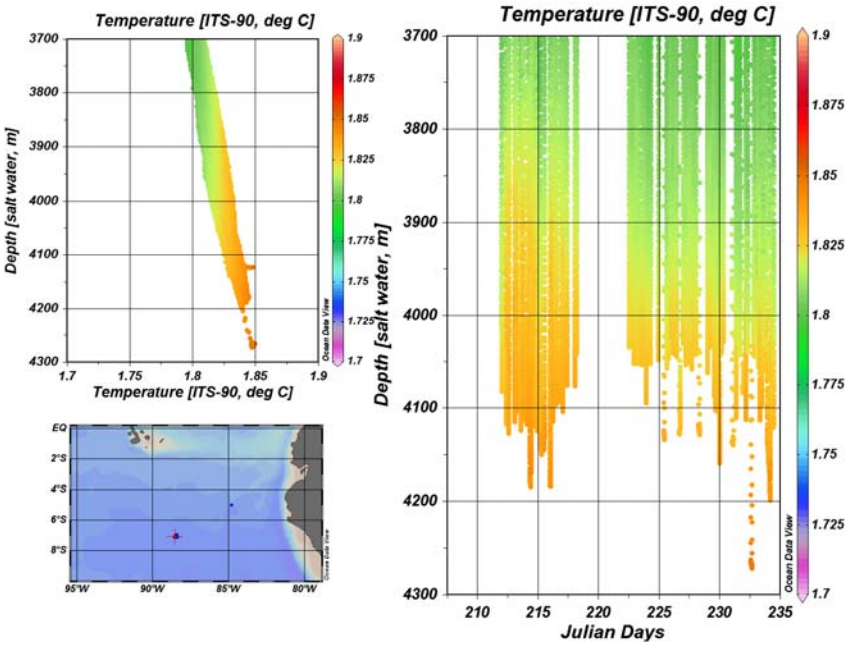


Figure 8.4.2.2: Bottom temperatures of the working areas and a reference station at the northeast.

The turbidity changes were recorded by the optical backscatter sensor of the MAPR in the DEA area,and the overview were shown by the figure 8.4.2_3. Almost all of the LBSS (offset to zero) were below 0.05 V, except that during the EBS sledded on the seafloor and the OFOS observation.

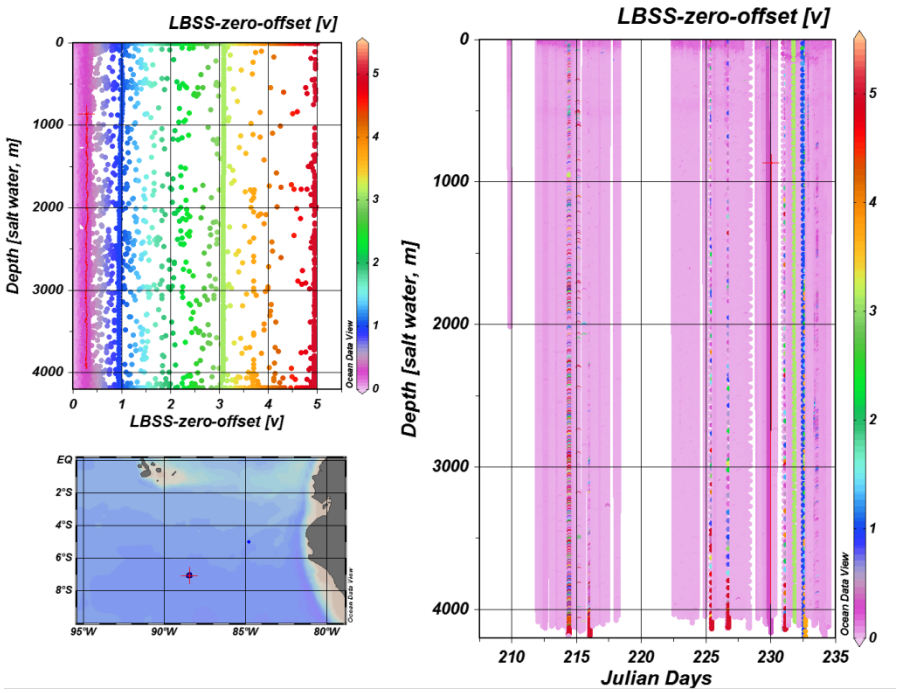


Figure 8.4.2.3: Overview of the turbidity changes in the DEA area.

8.4.3 BoBo, DOS lander and thermistor mooring

Henko de Stigter & Jens Greinert,

Thermistor mooring

The thermistor mooring was deployed on 30 July 2015 in an undisturbed area 3 nm south of the DEA circle. Recovery is planned to take place by the end of September 2015 during SO242/2. The mooring was launched from the stern of the ship, with top floats first and anchor last, spooling the mooring line directly from the drum without use of an additional block. The whole operation proceeded smoothly. The position of the mooring on the seabed was subsequently determined by ranging the IXSEA acoustic releasers from three different positions around the deployment position.

BoBo lander

The BOBO lander was deployed three times, the first time for 5 days in an undisturbed area 3 nm south of the DEA circle, the second time for 9 days within the DEA circle, and the third time for longer duration until end of September 2015 in the undisturbed area south of the DEA circle (Table xx). During both short deployments, a resuspension experiment was carried out in which the lander served for recording a sediment plume generated by towing the epibenthic sled (EBS) at relatively short distance along the lander. During all three deployments, the upward and downward facing ADCP's were set to record at 5 minute intervals. Since the lander's own Seabird 16plus CT was malfunctioning, it was replaced, together with the WetLabs ECO-FLNTURTD connected to it, with a Seabird 19 plus CTD and SeaPoint optical backscatter (OBS) sensor supplied by MUMM (L. Naudts). The CTD was also set to record at 5 minute intervals. In addition, a Sea&Sun CT supplied by Sea&Sun (J. Post) was added during the first short deployment, with sampling rate of 0.5 minute. The sediment trap was only used on the last, longer deployment, with a sampling rate set at 3 days. The sediment trap bottles were filled with bottom water collected during one of the CTD casts. No

chemical preservative was added to the water. Following the first two deployments, the position of the BoBo lander on the seabed was determined by ranging the Benthos acoustic releasers from three different positions around the deployment position. Because of time constraints this was not done during the third deployment.

From a first assessment of the data recorded during the two short deployments it appears that all instruments functioned properly. During the first deployment the upward-looking ADCP recorded consistent current velocity profiles to 30 m and occasionally up to 60 m above the lander, whilst during the second deployment the range was limited to about 20 m above the lander. The range may have been limited by the 20 m long pickup line and float extending vertically above the lander, producing deviating current velocity and acoustic backscatter measurements around 20 m above the lander. For comparison, the DOS lander which has a jack-in-the-box pickup line and float, consistently produced better results for the upward-looking ADCP, with a range generally over 40 m above the lander. Currents in the two short deployments displayed a distinct semi-diurnal tidal variation in both direction and magnitude (Fig. 8.4.3.1). On the longer term an anticyclonic motion was observed during the first 5-days deployment, whereas the mean current direction remained easterly during the second 9-days deployment. In both deployments, mean current speeds were around 3 cm s^{-1} and maxima did not exceed 10 cm s^{-1}. Current velocity at 1 m above the seabed recorded by the downward-looking ADCP was very similar to that measured in the overlying water column by the upward-looking ADCP. Records of relative bottom water turbidity measured as acoustic backscatter by the ADCP or as optical backscatter by the SeaPoint optical backscatter sensor showed no systematic correlation with current velocity, indicating that sediment resuspension by bottom currents was negligible. However, overall no consistent correlation was found between the different turbidity records (Fig. 8.4.3.2), presumably because of different sensitivity of the sensors used for different particle sizes and densities. Only the plume generated with the epibenthic sled on 4/5 August was well recorded by the downward-looking 1200 kHz ADCP as well as by the two optical backscatter sensors. The upward-looking 300 kHz ADCP, however, recorded no change or even a decrease in apparent turbidity (see further 8.5).

DOS Lander

During SO242/1 the DOS lander was deployed three times for short duration of 4, 7 and 5 days, in all cases within the DEA (SO242/1_#6_DOS-1, #42_DOS-2, #72_DOS-3). On these occasions a black and white checkerboard print was fixed on top of the lander, meant for calibration of photo images made by the AUV while passing over the lander. After this, the lander was once more deployed in the same area (SO242/1_#99_DOS-4), from where it will be recovered in late September during SO242/2. During all deployments, the ADCP and CTD were set to record at 5 minute intervals. Since the battery housing of the stereographic camera had been damaged by leakage during the previous deployment in the CCZ area during SO239, the lander was deployed without the camera. Following each deployment, the position of the lander on the seabed was determined by ranging the IXSEA acoustic releasers from three different positions around the deployment position.

Whilst the upward-looking ADCP performed better than the one on the BOBO lander, the recorded current velocities showed a good correspondence both in direction and magnitude (Fig. 8.4.3.1), despite that the two landers were several miles apart during their first deployment. The distinct semi-diurnal variability in current velocity, and the longer-term anticyclonic motion followed by a more persistent easterly water flow were also recorded by the DOS lander. The implication of the similarity in current patterns is that bottom water flow is primarily controlled by regional water

mass motions and that steering by local topography plays a subordinate role. The four optical backscatter sensors showed widely diverging patterns, so far unexplained (Fig. 8.4.3.2).

Table 8.4.3.1: Compilation of sensor settings during SO242/1 lander deployments

Station SO242/1_	Deployment time	Position (Lat., Lon., depth)	Instrument	Setting
#6_DOS1	2015/07/30 16:40:09	-7:04.308 -88:28.297 4140m	300kHz RDI ADCP upward looking SBE16 plus (broken CTD pump)	30 depth cells, 200cm cell size, 80 pings /ensemble, blank after transmit 176cm Sampling interval: 300 sec.
#36_DOS1	2015/08/03 4:13:00			
#11_BoBo1	2015/07/30 18:36:01 2015/08/05 15:20:29	-7:07.465 -88:26.086 4175m	300 kHz RDI ADCP upward looking 1200 kHz RDI ADCP downward looking SBE19 plus CTD Sea & Sun CT	30 depth cells, 200 cm cell size, 80 pings /ensemble, blank after transmit 176 cm 15 depth cells, 20 cm cell size, 50 pings /ensemble, blank after transmit 44 cm Sampling interval: 300 sec Sampling interval: 30 sec
#42_DOS-2	2015/08/04 1:21:31 2015/08/11 14:50:08	-7:04.476 -88:26.000 4200m	300kHz RDI ADCP upward looking SBE16 plus (pump disconnected) SBE19plus	60 depth cells, 100cm cell size, 80 pings /ensemble, blank after transmit 176cm Sampling interval: 300 sec. Sampling interval: 300 sec.
#57_BoBo-2	2015/08/06 17:56:24 2015/08/16 6:44:46	-7:04.750 -88:28.527 4141m	300 kHz RDI ADCP upward looking 1200 kHz RDI ADCP downward looking SBE19 plus CTD	30 depth cells, 200 cm cell size, 80 pings /ensemble, blank after transmit 176 cm 15 depth cells, 20 cm cell size, 50 pings /ensemble, blank after transmit 44 cm Sampling interval: 300 sec
#72_DOS-3	2015/08/11 18:29:59 2015/08/16 9:51:35	-7:04.583 -88:28.554 4116m	300kHz RDI ADCP upward looking SBE16 plus (pump disconnected SBE19plus	40 depth cells, 150cm cell size, 80 pings /ensemble, blank after transmit 176cm Sampling interval: 150 sec. Sampling interval: 60 sec.
#97_BoBo-3	2015/08/16 7:43:00	-7:07.422 -88:25.538 4162m	300 kHz RDI ADCP upward looking 1200 kHz RDI ADCP downward looking SBE19 plus CTD PPS4/3 sediment trap	30 depth cells, 200 cm cell size, 80 pings /ensemble, blank after transmit 15 depth cells, 20 cm cell size, 50 pings /ensemble, blank after transmit 44 cm Sampling interval: 300 sec 12 samples of 3 days each, start 17 August 2015 00:01 h
#99_DOS-4	2015/08/16 15:00:14	-7:04.268 -88:28.961 4131m	300kHz RDI ADCP upward looking SBE16 plus (pump disconnected SBE19plus	60 depth cells, 100cm cell size, 80 pings /ensemble, blank after transmit 176cm Sampling interval: 300 sec. Sampling interval: 300 sec.

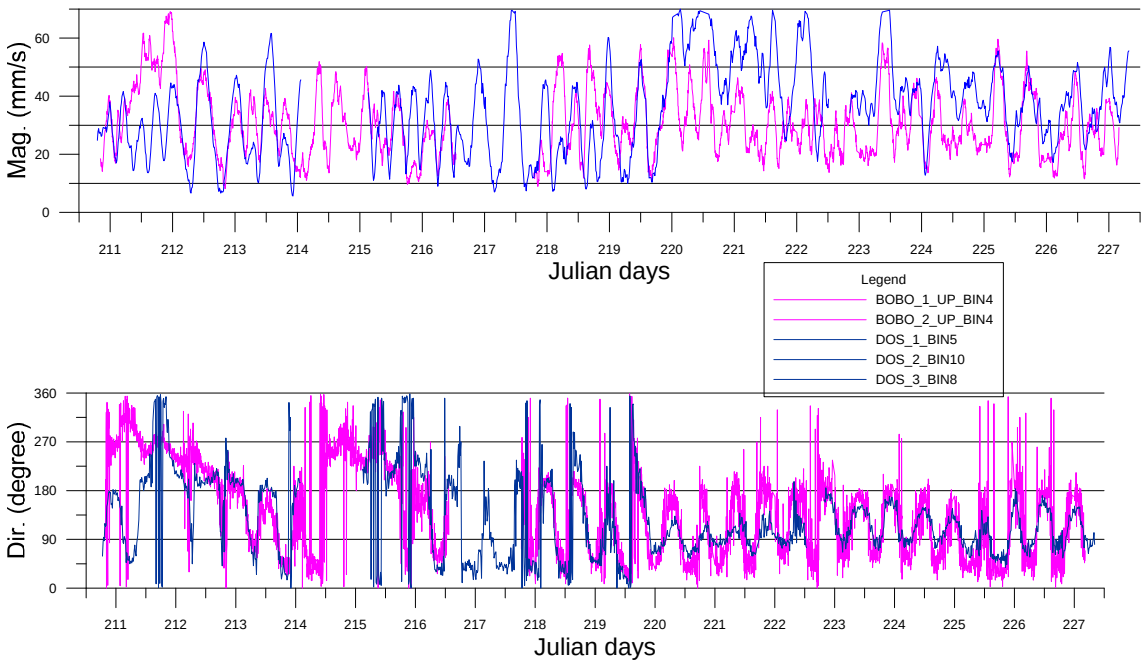


Figure 8.4.3.1: Current speed (mm s^{-1}) and direction (°N)at approximately 15 m above bottom recorded in successive BoBo and DOS lander deployments. Note overall correspondence in short and longer term current variation recorded by the BOBO and DOS lander, despite the different locations where the landers have been deployed.

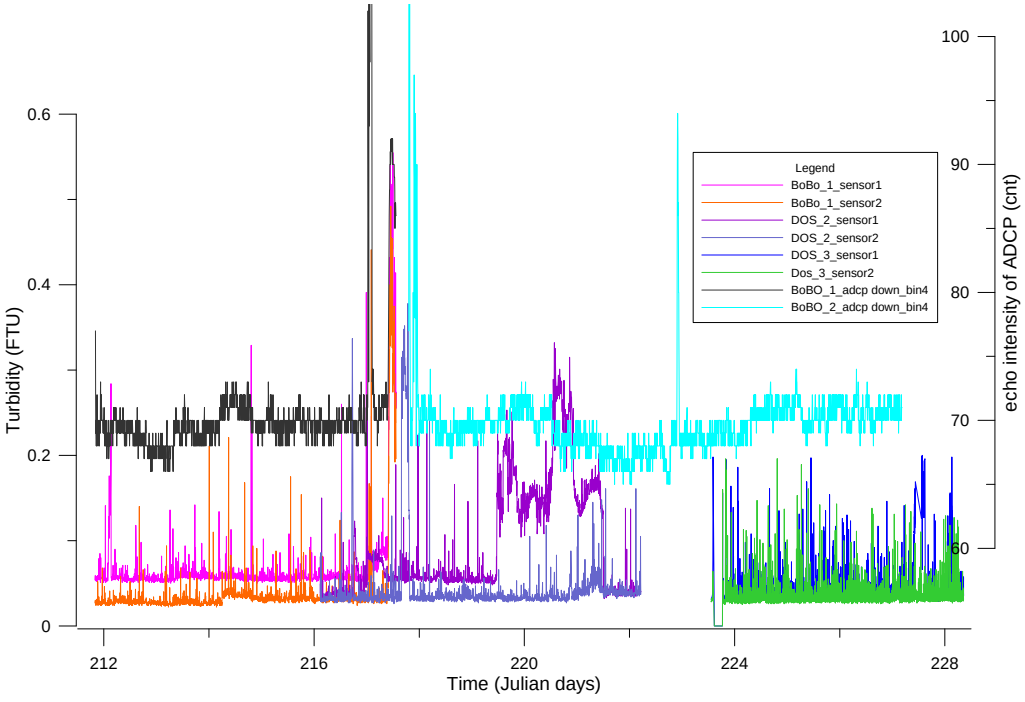


Figure 8.4.3.2: Time-series of relative turbidity recorded with optical and acoustic sensors on the BOBO and DOS lander, showing generally very little correspondence between simultaneous measurements . The exception are two peaks in turbidity recorded on day 217 by both the downward looking ADCP (black line) and two optical sensors (orange and magenta lines), which reflect passage of the plume generated with the epibenthic sled.

8.4.4 EBS-disturbance experiments

Cuiling Xu, Henko de Stigter, Jens Greinert

Two disturbance experiments were carried out in the DISCOL area to study the sediment plume dispersal in the water column. The sediment plume was created during two Epibenthic sled deployments; water currents and backscatter by the ADCP and turbidity sensors of the DOS lander and BoBo lander were used and the EBS was towed close to the landers.

Experiment 1

During this experiment east of the Reference Area South EBS-1 and EBS-2 were used for disturbing and BoBo-1 was the lander for recording the plume. The position and times are shown in the Table 1 and current trajectories of sediment plume relative to the BoBo lander is shown in Figure 8.4.4.1.

Table 8.4.4.1: the position and running time of EBS_1, EBS_2 and BoBo_1 (the position of EBS_1 measure by ship navigation, while the two others from UBSL position).

Station	UTC time	Position (Lat., Lon.)	
EBS-1 start	2015-8-39:03:05	-7:07.276	-88:26.140
EBS-1 end	2015-8-39:24:41	-7:07.754	-88:25.588
EBS-2 start	2015-8-50:36:53	-7:07.150	-88:26.322
EBS-2 end	2015-8-50:59:30	-7:07.532	-88:25.984
BoBo-1 start	2015-7-30 18:37	-7:7.465,	-88:26.086
BoBo-1 end	2015-8-5 15:20		

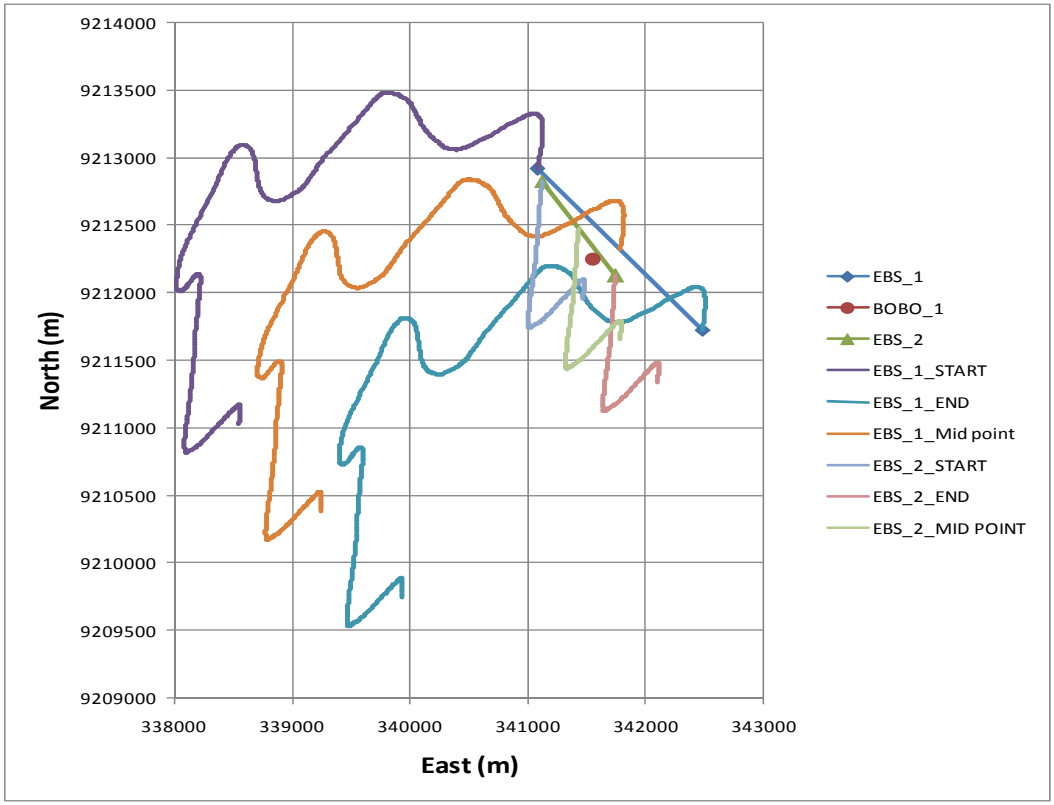


Figure 8.4.4.1: Left, the position of EBS-1, EBS-2 and BoBo-1 (in UTM coordinate), and the trajectory of the sediment plume calculated by the water current data of the BoBo-1 downward looking ADCP (bin 3;).

A more detailed illustration of the second EBS tow is shown in Figure 8.4.4.2.

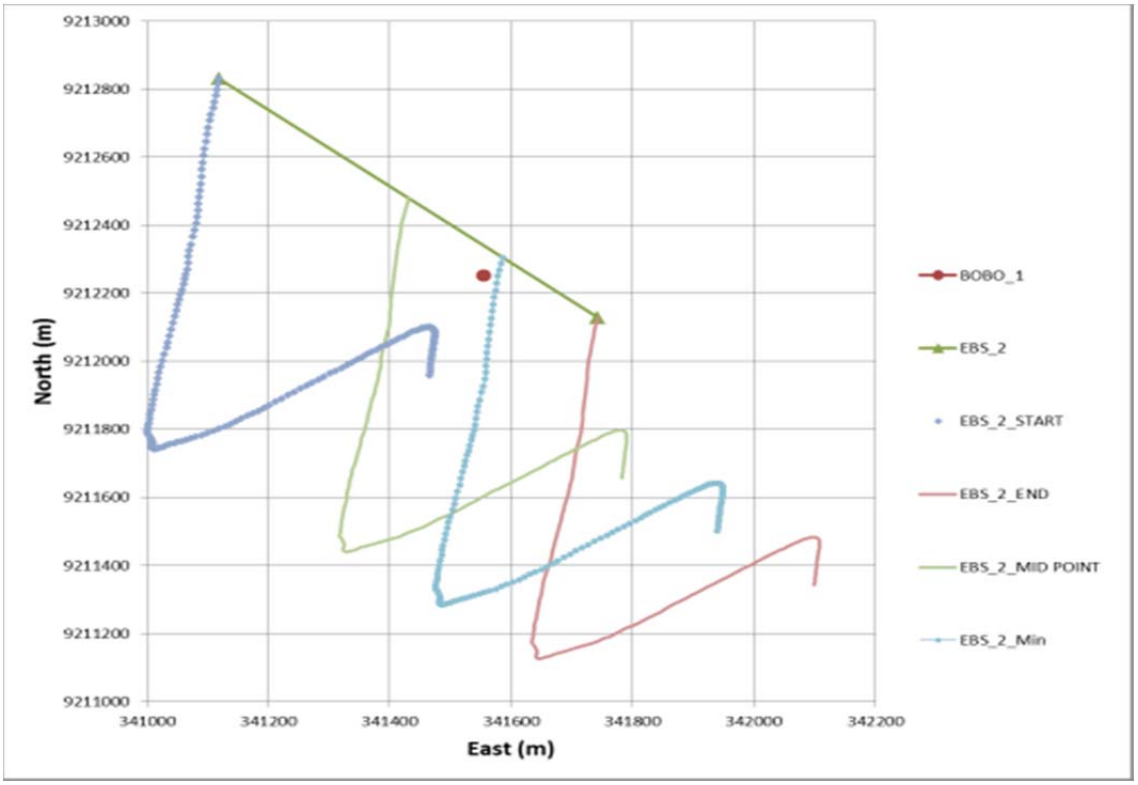


Figure 8.4.4.2: Details of EBS-2 and BoBo-1. The currents are directly oriented towards the BoBo lander and EBS-2 only passed 40m of BoBo.

During station EBS-1 the seafloor was disturbed between 9:03:05 and 9:24:41 on 3rd August 2015. During this time the bottom water current moved first northward for 2h and changed towards a southwest direction. A 'sediment charged' water mass arrived 5.5 hours after the EBS disturbance. The echo backscatter of both the upward and downward ADCP did not record clear signs of turbidity, implying that the sediment plume settled before that.

During EBS-2, the bottom water current moved southward, reaching the BoBo lander after only 10 minutes. The downward looking ADCP recorded a significant increase of backscatter. A second elevated backscatter signal can be linked to an already spread out sediment plume that reach BoBo. After about 5 hours where the water moved southward it turned towards a NE direction and reached the lander position after ca. 10h. Comparing to the first well visible and defined high backscatter signal with the second one (staring from ensemble 1630 in Figure 8.4.4.3 & 4) one gets the impression of a more diffuse and from the bottom detached sediment plume. Although the currents measured by the upward looking ADCP were similar to the downward looking ADCP, the upward ADCP did not show elevated backscatter signals. This might be because the plume did not reach the measure height of 10.64 m above the seafloor, or the ADCP frequency of 300Hz is not sensitive enough to slightly increased turbidity. The turbidity data measured by two OBS sensors of the CTD are shown in Figure 8.4.4.5 in relation to the ADCP backscatter values. The sensors also recorded two peaks at the same time as the ADCP. In the OBS data the first peak was less intense than the second one.

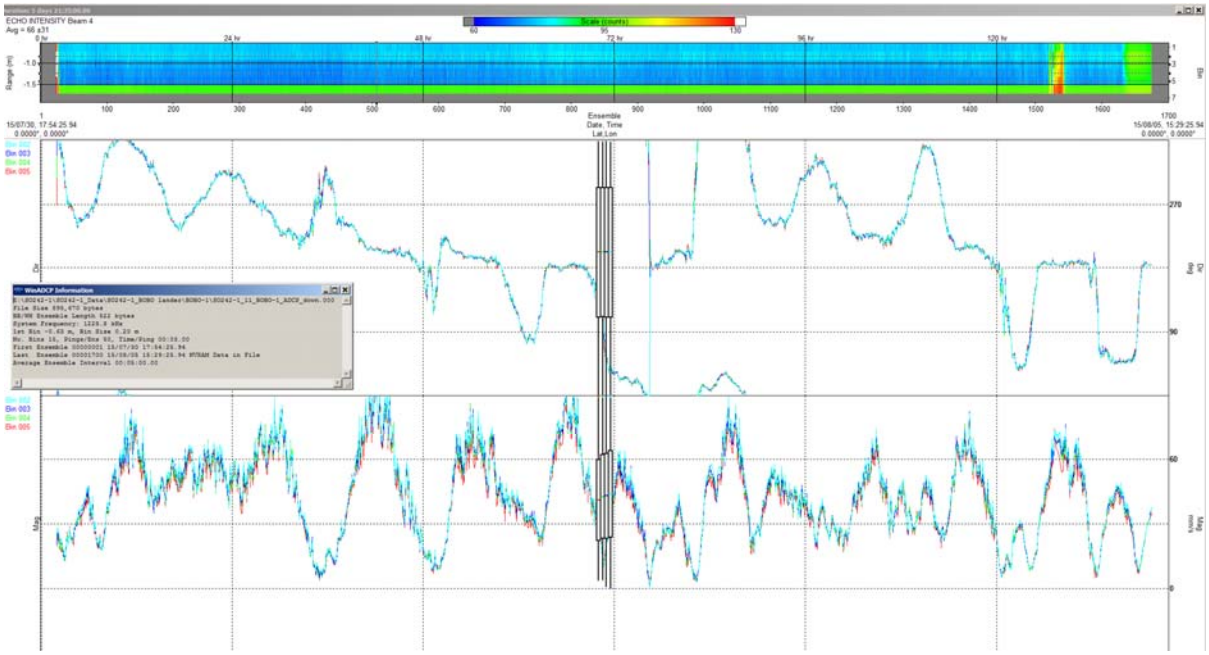


Figure 8.4.4.3: ADCP backscatter and current data of the downward looking 1200kHz data of station #11_BoBo-1. The entire data set is shown

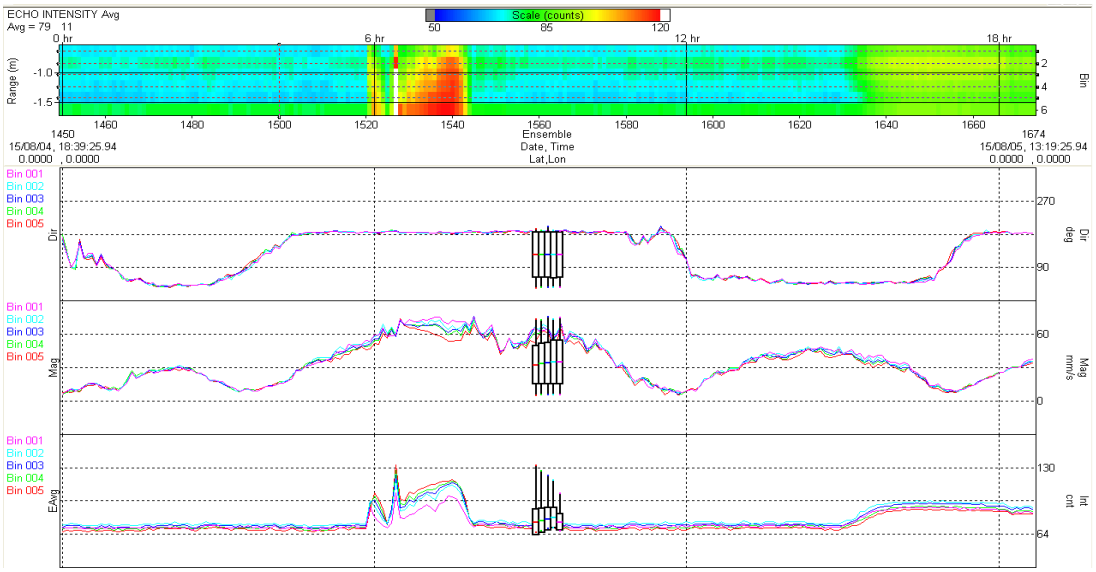


Figure 8.4.4.4: ADCP backscatter and current data of the downward looking 1200kHz data of station #11_BoBo-1. Only the last section of the data set is shown

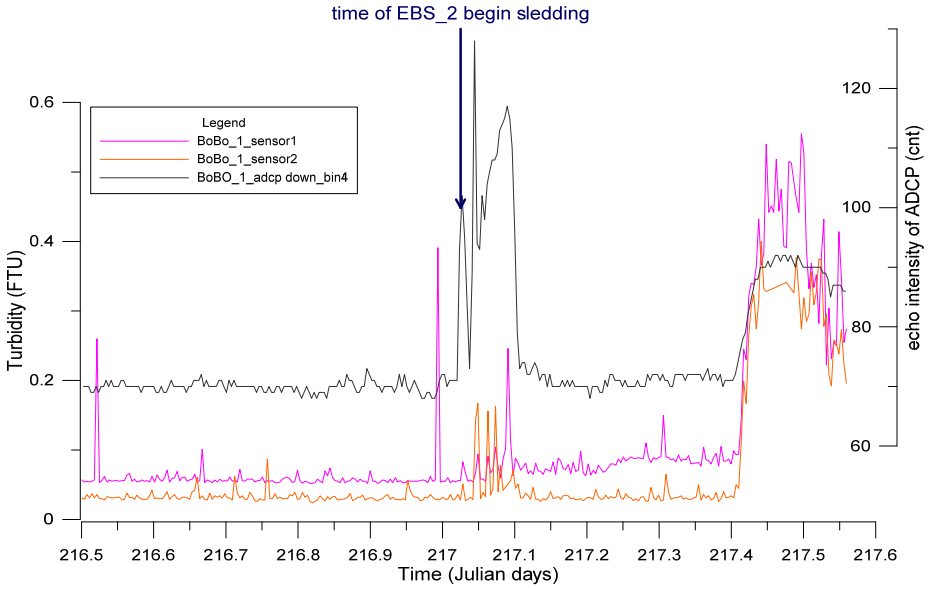


Figure 8.4.4.5: Comparison between OBS and ADCP backscatter data of the two plume signals detected.

Experiment 2

The second experiment was conducted in the western part of the DEA. The related stations include EBS-3, BoBo-2 and DOS-3 (Table 8.4.4.2). The ADCP of both the BoBo and DOS lander did not record any signs of a sediment plume as the water move mainly toward SE and away from the two landers.

Table 8.4.4.2: Position and deployment time of EBS-3, BoBo-2 and DOS-3

Station	UTC time	Position (Lat., Lon.)	
EBS-3 start	2015-8-13 12:03:18	-7:05.322	-88:28.005
EBS-3 end	2015-8-13 12:55:49	-7:05.357	-88:27.804
DOS-3 start	2015-8-11 18:30	-7:04.583	-88:28.554
DOS-3 end	2015-8-16 09:51		
BoBo-2 start	2015-8-6 17:35	-7:04.697	-88:28.497
BoBo-2 end	2015-8-16 06:50		

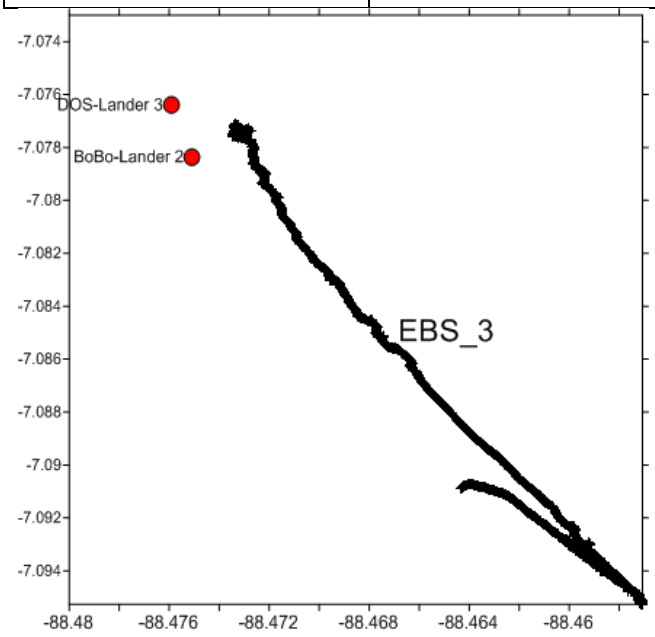
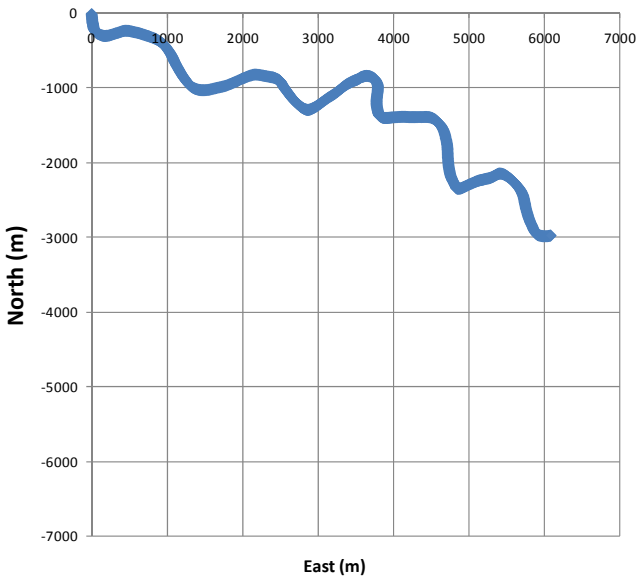


Figure 8.4.4.6: Top, USBL data of EBS-3, and the locations of the BoBo-2 and DOS-3. Bottom, trajectory of the sediment plume of the BoBo 1200kHz ADCP during the EBS station.



8.5 Geotechnical studies

During the SO242-1 cruise a number of 52 shear-strength measurements were carried out within 25 box corer samples. These measurements were carried out with the a.m. handhold shear-strength probe directly after the first sampling of micro-fauna on the sediment surface and on top of the Mn-nodules. In general two vertical shear-strength profiles were measured at each box corer sample. Most profiles showed similar profiles with steadily increasing values from the uppermost 10 cm level (2 – 4 kPa) to lowest layer at 40 cm (15 – 25 kPa). Shear-strength values measured in disturbed areas often revealed a vertical profile which had the maximum shear-strength value at the 20 cm layer und the deeper layer (30 or 40 cm) showed a lower shear-strength value. In general the uppermost layer within the disturbed area revealed very low shear-strength values (0 – 2 kPa). Data are presented in Appendix 9.3.

8.6 References

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9 Appendix
9.1 Station List

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_1-1	CTD 1	2015/07/29	19:58:14	-5:00.584	-84:47.309			Max depth	releaser test at 2000m water depth	Transit	4010.4
242-1_2-1	EM 122	2015/07/29	21:44:17	-5:00.947	-84:47.146			Station start		Transit	4009.7
242-1_2-1	EM 122	2015/07/30	16:33:58	-7:04.083	-88:28.295			Station end	Multibeam profile of transit ended, when the first Station in the DISCOL area was reached	Transit	4132
242-1_3-1	LBL-1	2015/07/30	16:03:00	-7:03.396	-88:26.780			Deployment		DEA	4088.2
242-1_4-1	missing stattion number								wrong use of the DSHIP software		
242-1_5-1	LBL-2	2015/07/30	16:25:08	-7:03.351	-88:28.593			Deployment		DEA	4149.7
242-1_6-1	DOS-Lander 1	2015/07/30	16:40:09	-7:04.308	-88:28.297			Deployment		DEA	4123.6
242-1_36-1	DOS-Lander 1	2015/08/03	4:13:00	-7:04.589	-88:29.290			Recovery		DEA	4144
242-1_7-1	missing stattion number								wrong use of the DSHIP software		
242-1_8-1	Amphi-Trap 1	2015/07/30	17:02:36	-7:04.066	-88:27.487	-7:04.066	-88:27.487	Deployment		DEA	4145.7
242-1_8-1	Amphi-Trap 1	2015/08/01	16:29:09	-7:04.174	-88:27.894			Recovery		DEA	4144
242-1_9-1	LBL-3	2015/07/30	17:36:44	-7:05.305	-88:28.655			Deployment		DEA	4163.9
242-1_10-1	LBL-4	2015/07/30	18:05:19	-7:05.356	-88:26.654			Deployment		DEA	4151.1
242-1_11-1	BoBo-Lander 1	2015/07/30	18:36:01	-7:07.428	-88:26.002	-7:07.465	-88:26.086	Deployment	Depth at landing site 4175m	Ref south	4155.9
242-1_11-1	BoBo-Lander 1	2015/08/05	15:20:29	-7:07.638	-88:26.316			Recovery		Ref south	4171
242-1_12-1	Thermistor Mooring 1	2015/07/30	19:43:06	-7:07.408	-88:24.047			Deployment		W of Ref south	4237
242-1_13-1	LBL Calibration	2015/07/30	20:13:53	-7:05.879	-88:26.617			Survey		DEA	4134

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_14-1	missing stattion number								wrong use of the DSHIP software		
242-1_15-1	AUV 1	2015/07/31	3:13:31	-7:04.353	-88:27.624			Deployment	Abyss#0187; SSS and camera test; aborted	DEA	4134.4
242-1_15-1	AUV 1	2015/07/31	3:51:48	-7:04.154	-88:28.537			Recovery		DEA	4133
242-1_16-1	CTD 2	2015/07/31	5:49:23	-7:03.980	-88:28.591			Max depth		DISCOL	4137.3
242-1_17-1	EM 122	2015/07/31	8:29:44	-6:59.086	-88:19.952			Station start		DISCOL	4275.6
242-1_17-1	EM 122	2015/07/31	16:31:23	-7:07.132	-88:20.117			Station end		DISCOL	4116
242-1_18-1	AUV 2	2015/07/31	18:00:00	-7:04.393	-88:27.604			Deployment	Abyss#0188; SSS and camera test	DEA	4154.8
242-1_18-1	AUV 2	2015/07/31	21:33:00					Start mission	see Cruise Report	DEA	
242-1_18-1	AUV 2	2015/08/01	7:53:00					End mission	see Cruise Report	DEA	
242-1_23-1	AUV 2	2015/08/01	10:17:26	-7:04.192	-88:28.695			Recovery		DEA	4139.4
242-1_19-1	MUC 1	2015/07/31	23:42:37	-7:07.518	-88:27.018	-7:07.5058	-88:27.0584	on ground	empty	Ref south	4161.4
242-1_20-1	BC 1	2015/08/01	3:14:59	-7:07.531	-88:27.033	-7:07.5448	-88:27.0487	on ground		Ref south	4161.8
242-1_21-1	Lander Triangulation	2015/08/01	4:54:41	-7:07.531	-88:27.040	-7:04.237	-88:28.362	Station start		Ref south	4155.5
242-1_22-1	MUC 2	2015/08/01	8:18:13	-7:07.542	-88:27.021			on ground	empty	Ref south	4139.4
242-1_24-1	MUC 3	2015/08/01	13:48:38	-7:07.519	-88:27.026	-7:07.5282	-88:27.0739	on ground	empty	Ref south	4162.9
242-1_25-1	AUV 3	2015/08/01	16:51:16	-7:04.383	-88:27.673			Deployment	Abyss#0189; SSS and camera test	DEA	4153.5
242-1_25-1	AUV 3	2015/08/01	19:31:00					Start mission	see Cruise Report	DEA	
242-1_25-1	AUV 3	2015/08/02	4:48:00					End mission	see Cruise Report	DEA	
242-1_25-1	AUV 3	2015/08/02	9:49:20	-7:04.665	-88:29.650			Recovery		DEA	4154
242-1_26-1	BC 2	2015/08/01	20:04:23	-7:07.536	-88:27.002			on ground	no Posidonia signal	Ref south	4163.6
242-1_27-1	BC 3	2015/08/02	0:46:54	-7:07.548	-88:27.029			on ground	no Posidonia signal	Ref south	4139.4
242-1_28-1	MUC 4	2015/08/02	4:29:25	-7:07.532	-88:27.051			on ground	empty	Ref south	4159.5
242-1_29-1	MUC 5	2015/08/02	6:21:55	-7:07.514	-88:27.003			in the water		Ref south	4159.7
242-1_29-1	MUC 5	2015/08/02	6:49:30	-7:07.510	-88:27.001			On deck	empty	Ref south	4160
242-1_29-1	MUC 5	2015/08/02	7:02:02	-7:07.510	-88:27.000			in the water		Ref south	4162.2
242-1_29-1	MUC 5	2015/08/02	7:51:41	-7:07.512	-88:27.006			On deck	empty	Ref south	4163.7

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_30-1	Amphi-Trap 2	2015/08/02	11:02:20	-7:09.387	-88:23.610	-7:09.588	-88:23.749	Deployment		S of DISCOL	4307.4
242-1_30-1	Amphi-Trap 2	2015/08/04	17:13:38	-7:09.722	-88:24.061			Recovery		S of DISCOL	4269
242-1_31-1	BC 4	2015/08/02	13:35:05	-7:07.556	-88:27.001	-7:07.5765	-88:27.0148	on ground		Ref south	4167
242-1_32-1	BC 5	2015/08/02	16:57:26	-7:07.528	-88:27.024	-7:07.5396	-88:27.0389	on ground		Ref south	4162.1
242-1_33-1	AUV 4	2015/08/02	19:12:32	-7:04.375	-88:27.668			Deployment	Abyss#0190; SSS and camera	DEA	4152.6
242-1_33-1	AUV 4	2015/08/02	21:30:00					Start mission	see Cruise Report	DEA	
242-1_33-1	AUV 4	2015/08/03	7:38:00					End mission	see Cruise Report	DEA	
242-1_33-1	AUV 4	2015/08/03	13:05:06	-7:04.422	-88:30.524			Recovery		DEA	4120.8
242-1_34-1	MUC 6	2015/08/02	21:27:28	-7:07.517	-88:27.029	-7:07.524	-88:27.031	on ground		Ref south	4161.7
242-1_35-1	MUC 7	2015/08/03	1:53:21	-7:07.541	-88:27.026	-7:07.558	-88:27.047	on ground		Ref south	4159.9
242-1_37-1	EBS 1	2015/08/03	5:21:27	-7:07.097	-88:26.341			Station start		Ref south	4198
242-1_37-1	EBS 1	2015/08/03	8:02:17	-7:07.276	-88:26.140	-7:07.686	-88:25.706	on ground	EBS on ground	Ref south	4167.3
242-1_37-1	EBS 1	2015/08/03	9:24:41	-7:07.754	-88:25.588	-7:07.854	-88:25.484	off ground	EBS off ground	Ref south	4176.3
242-1_37-1	EBS 1	2015/08/03	10:51:37	-7:07.751	-88:25.588			On deck		Ref south	4176.6
242-1_38-1	GC 1	2015/08/03	15:24:44	-7:07.521	-88:27.024	-7:07.537	-88:27.047	on ground		Ref south	4160.9
242-1_39-1	MUC 8	2015/08/03	18:41:03	-7:07.516	-88:27.029	-7:07.523	-88:27.039	on ground		Ref south	4162.2
242-1_40-1	MUC 9	2015/08/03	22:18:22	-7:07.542	-88:27.022	-7:07.538	-88:27.034	on ground		Ref south	4163.9
242-1_41-1	AUV 5	2015/08/04	0:35:26	-7:04.457	-88:27.591			Deployment	Abyss#0191; SSS and camera	Ref west	4151.1
242-1_41-1	AUV 5	2015/08/04	2:41:00					Start mission	see Cruise Report	Ref west	
242-1_41-1	AUV 5	2015/08/04	12:17:00					End mission	see Cruise Report	Ref west	
242-1_41-1	AUV 5	2015/08/04	15:22:06	-7:08.035	-88:28.273			Recovery		Ref west	4194.5
242-1_42-1	DOS-Lander 2	2015/08/04	1:21:31	-7:04.476	-88:26.000			Deployment		Ref south	4199.2
242-1_42-1	DOS-Lander 2	2015/08/11	14:50:08	-7:04.983	-88:27.140			Recovery		Ref south	4149.9
242-1_43-1	OFOS 1	2015/08/04	1:44:38	-7:04.389	-88:27.951			Station start		DEA	4148.4
242-1_43-1	OFOS 1	2015/08/04	3:50:37	-7:04.345	-88:27.927	-7:04.342	-88:27.975	on ground		DEA	4142
242-1_43-1	OFOS 1	2015/08/04	12:35:43	-7:04.445	-88:27.004	-7:04.394	-88:26.870	off ground		DEA	4146
242-1_43-1	OFOS 1	2015/08/04	14:29:06	-7:04.432	-88:27.188			On deck		Dea	4148.5
242-1_44-1	MUC 10	2015/08/04	19:21:44	-7:07.507	-88:26.998			on ground		Ref south	4159.8
242-1_45-1	EBS 2	2015/08/04	21:36:22	-7:07.116	-88:26.356			Station start		Ref south	4184
242-1_45-1	EBS 2	2015/08/04	23:40:21	-7:07.333	-88:26.121	-7:07.150	-88:26.322	on ground	EBS on ground	Ref south	4195

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_45-1	EBS 2	2015/08/05	0:59:30	-7:07.935	-88:25.554	-7:07.532	-88:25.984	off ground	EBS off Grund	Ref south	4169.7
242-1_45-1	EBS 2	2015/08/05	3:00:06	-7:07.456	-88:26.139			Station end		Ref south	4163.3
242-1_46-1	MUC 11	2015/08/05	5:30:12	-7:07.530	-88:27.010	-7:07.534	-88:27.025	on ground		Ref south	4162.1
242-1_47-1	AUV 6	2015/08/05	7:48:44	-7:04.358	-88:27.658			Deployment	Abyss#0192; MB	DEA	4163.6
242-1_47-1	AUV 6	2015/08/05	11:42:00					Start mission	see Cruise Report		
242-1_47-1	AUV 6	2015/08/05	22:58:00					End mission	see Cruise Report		
242-1_47-1	AUV 6	2015/08/06	3:13:32	-7:05.868	-88:30.307			Recovery		DEA	4147.3
242-1_48-1	BC 6	2015/08/05	9:35:30	-7:04.414	-88:27.834	-7:04.413	-88:27.839	on ground		DEA (heavily disturbed)	4144.4
242-1_49-1	BC 7	2015/08/05	12:42:19	-7:04.412	-88:27.839	-7:04.420	-88:27.852	on ground		DEA (heavily disturbed)	4142.4
242-1_50-1	CTD 3	2015/08/05	17:49:13	-7:07.357	-88:23.572			Max depth	Data lost	Ref south	4256.4
242-1_51-1	GC 2	2015/08/05	21:50:38	-7:04.409	-88:27.826	-7:04.411	-88:27.836	on ground		DEA (heavily disturbed)	4147.7
242-1_52-1	BC 8	2015/08/06	1:05:02	-7:04.404	-88:27.835	-7:04.411	-88:27.844	on ground		DEA (heavily disturbed)	4145.6
242-1_53-1	BC 9	2015/08/06	5:11:19	-7:04.414	-88:27.864	-7:04.423	-88:27.879	on ground		DEA (heavily disturbed)	4146.3
242-1_54-1	BC 10	2015/08/06	8:33:55	-7:04.395	-88:27.846	-7:04.419	-88:27.844	on ground		DEA (heavily disturbed)	4149.8
242-1_55-1	Amphi-Trap 3	2015/08/06	11:33:10	-7:07.129	-88:32.962	-7:07.131	-88:32.977	Deployment		South of western ref area	4043.3
242-1_55-1	Amphi-Trap 3	2015/08/07	15:32:19	-7:07.475	-88:33.323			Recovery		South of western ref area	4089.5
242-1_56-1	MUC 12	2015/08/06	15:32:28	-7:04.346	-88:27.644	-7:04.414	-88:27.760	on ground		DEA (heavily disturbed)	4149
242-1_57-1	BoBo-Lander 2	2015/08/06	17:56:24	-7:04.697	-88:28.497	-7:04.750	-88:28.527	Deployment	Depth at landing site 4131m	DEA	4141
242-1_57-1	BoBo-Lander 2	2015/08/16	6:44:46	-7:04.311	-88:28.769			Recovery		DEA	4144.9
242-1_58-1	CTD 4	2015/08/06	20:08:45	-7:04.705	-88:28.498			Max depth		DEA	4140.8

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_59-1	wrong station number								wrong use of the DSHIP software		
242-1_60-1	AUV 7	2015/08/06	22:45:42	-7:04.471	-88:27.652			Deployment	Abyss#0193; MB	DEA	
242-1_60-1	AUV 7	2015/08/07	0:48:00					Start mission	see Cruise Report		
242-1_60-1	AUV 7	2015/08/07	10:26:00					End mission	see Cruise Report		
242-1_60-1	AUV 7	2015/08/07	13:32:40	-7:05.556	-88:29.767			Recovery		DEA	4168.4
242-1_61-1	MUC 13	2015/08/07	1:03:01	-7:04.275	-88:27.790	-7:04.378	-88:27.781	on ground		DEA (heavily disturbed)	4148
242-1_62-1	MUC 14	2015/08/07	4:41:44	-7:04.424	-88:27.862	-7:04.473	-88:27.877	on ground		DEA (heavily disturbed)	4154.4
242-1_63-1	missing stattion number								wrong use of the DSHIP software		
242-1_64-1	MUC 15	2015/08/07	7:58:01	-7:04.421	-88:27.851	-7:04.466	-88:27.865	on ground		DEA (heavily disturbed)	4153.5
242-1_65-1	MUC 16	2015/08/07	11:17:58	-7:04.419	-88:27.855	-7:04.422	-88:27.850	on ground		DEA (heavily disturbed)	4151.6
242-1_66-1	EM 122	2015/08/07	17:26:05	-7:00.815	-88:12.852			Profile start		Transit	4070.9
242-1_66-1	EM 122	2015/08/08	11:00:31	-5:08.450	-84:45.972			Information	break in data recording	Transit	3996.9
242-1_66-1	EM 122	2015/08/08	15:48:52	-4:55.115	-84:21.625			Profile end		Transit	3962.2
242-1_67-1	EM 122	2015/08/10	12:55:25	-4:56.048	-84:45.572			Profile start		Transit	3987.6
242-1_67-1	EM 122	2015/08/10	13:38:47	-4:58.983	-84:54.043			Information	Parasound recording started	Transit	3999.6
242-1_67-1	EM 122	2015/08/11	7:32:05	-6:52.079	-88:12.768			Profile end		Transit	4086.1
242-1_67-1	EM 122	2015/08/11	8:16:00	-6:48.194	-88:15.026			Profile start		Transit	4116.1
242-1_67-1	EM 122	2015/08/11	9:20:12	-6:56.036	-88:25.832			Profile end		Transit	4162.3
242-1_68-1	Amphi-Trap 4	2015/08/11	7:39:46	-6:52.128	-88:12.723			Deployment	no Posidonia signal	NE of DISCOL	4077.6
242-1_68-1	Amphi-Trap 4	2015/08/14	4:00:22	-6:52.296	-88:13.199			Recovery		NE of DISCOL	4117.9
242-1_69-1	AUV 8	2015/08/11	10:30:49	-7:04.450	-88:27.735			Deployment	Abyss#0194; MB	DEA	4198
242-1_69-1	AUV 8	2015/08/11	12:41:00					Start mission	see Cruise Report	see Cruise Report	

Station Number	Device	Date	Time (UTC)	Ship Position		Device Position		Action	Comment	Area	Water Depth
		[yyyy/mm/dd]	[hh:mm:ss]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]	Latitude [dd:mm.mmm]	Longitude [dd:mm.mmm]				[m]
242-1_69-1	AUV 8	2015/08/11	21:43:00					End mission	see Cruise Report	see Cruise Report	
242-1_69-1	AUV 8	2015/08/12	1:41:41	-7:04.480	-88:28.236			Recovery		DEA	4140.5
242-1_70-1	MUC 17	2015/08/11	12:43:52	-7:04.373	-88:27.779	-7:04.400	-88:27.778	on ground		DEA (heavily disturbed)	4127.5
242-1_71-1	MUC 18	2015/08/11	17:51:36	-7:04.485	-88:27.849				empty	DEA (heavily disturbed)	4127.6
242-1_72-1	DOS-Lander 3	2015/08/11	18:29:59	-7:04.586	-88:28.545	-7:04.583	-88:28.554	Deployment	Triangulation; water depth at landing site is 4116 m	DEA	4129.9
242-1_72-1	DOS-Lander 3	2015/08/16	9:51:35	-7:04.562	-88:28.815			Recovery		DEA	4143
242-1_73-1	MUC 19	2015/08/11	21:53:01	-7:04.358	-88:27.889	-7:04.407	-88:27.895	on ground		DEA (heavily disturbed)	4121.1
242-1_74-1	MUC 20	2015/08/12	4:39:16	-7:03.901	-88:27.085	-7:03.945	-88:27.097	on ground		Black Patch	4150
242-1_75-1	AUV 9	2015/08/12	7:26:21	-7:04.401	-88:27.620			Deployment	Abyss#0195; MB	DEA	4154.2
242-1_75-1	AUV 9	2015/08/12	10:03:00					Start mission	see Cruise Report	see Cruise Report	
242-1_75-1	AUV 9	2015/08/12	21:23:00					End mission	see Cruise Report	see Cruise Report	
242-1_75-1	AUV 9	2015/08/13	0:27:35	-7:04.143	-88:28.791			Recovery		DEA	4138.1
242-1_76-1	OFOS 2	2015/08/12	9:08:11	-7:04.303	-88:32.420			Station start		Ref west	4129.1
242-1_76-1	OFOS 2	2015/08/12	10:33:11	-7:04.309	-88:32.427	-7:04.336	-88:32.398	on ground		Ref west	4131.3
242-1_76-1	OFOS 2	2015/08/12	14:32:33	-7:04.310	-88:30.760	-7:04.072	-88:30.976	off ground		Ref west	4141
242-1_76-1	OFOS 2	2015/08/12	15:56:56	-7:04.346	-88:31.041			On deck		Ref west	4116.6
242-1_77-1	BC 11	2015/08/12	18:25:10	-7:04.574	-88:31.567	-7:04.574	-88:31.577	on ground		Ref west	4130.5
242-1_78-1	BC 12	2015/08/12	21:55:54	-7:04.551	-88:31.559	-7:04.554	-88:31.564	on ground		Ref west	4131.2
242-1_79-1	MUC 21	2015/08/13	3:00:17	-7:04.597	-88:31.608	-7:04.596	-88:31.619	on ground		Ref west	4133.7
242-1_80-1	MUC 22	2015/08/13	6:57:23	-7:04.538	-88:31.576	-7:04.542	-88:31.581	on ground		Ref west	4129.5
242-1_81-1	EBS 3	2015/08/13	9:10:10	-7:03.442	-88:28.903			Station start		DEA	4152.9
242-1_81-1	EBS 3	2015/08/13	11:13:38	-7:05.322	-88:28.005			on ground	EBS on ground / no Posidonia signal	DEA	4162
242-1_81-1	EBS 3	2015/08/13	12:55:49	-7:05.756	-88:27.367	-7:05.357	-88:27.804	off ground	EBS off ground	DEA	4166

242-1_81-1	EBS 3	2015/08/13	14:31:45	-7:05.378	-88:27.976			On deck		DEA	4163.3
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_82-1	CTD 5	2015/08/13	18:12:21	-7:04.890	-88:28.143			Max depth		DEA	4146
242-1_83-1	AUV 10	2015/08/13	20:12:21	-7:04.391	-88:27.662			Deployment	Abyss#0196 camera	DEA	4151.2
242-1_83-1	AUV 10	2015/08/13	22:30:00					Start mission	see Cruise Report	see Cruise Report	
242-1_83-1	AUV 10	2015/08/14	8:15:00					End mission	see Cruise Report	see Cruise Report	
242-1_83-1	AUV 10	2015/08/14	13:12:18	-7:04.967	-88:30.857			Recovery		DEA	4105.4
242-1_84-1	GC 3	2015/08/13	22:37:03	-7:03.929	-88:27.090	-7:03.951	-88:27.093	on ground		Black Patch	4146
242-1_85-1	EBS 4	2015/08/14	6:54:56	-7:03.720	-88:29.356			Station start		DEA	4138
242-1_85-1	EBS 4	2015/08/14	8:43:11	-7:04.738	-88:28.138			on ground	EBS on ground / no Posidonia signal	DEA	4139.7
242-1_85-1	EBS 4	2015/08/14	10:22:11	-7:05.290	-88:27.475			off ground	EBS off ground	DEA	4158.9
242-1_85-1	EBS 4	2015/08/14	11:55:11	-7:05.303	-88:27.471			On deck		DEA	4151.5
242-1_86-1	BC 13	2015/08/14	15:09:25	-7:04.622	-88:31.538	-7:04.627	-88:31.559	on ground		Ref west	4129.5
242-1_87-1	BC 14	2015/08/14	18:22:42	-7:04.612	-88:31.559	-7:04.604	-88:31.563	on ground		Ref west	4123.4
242-1_88-1	AUV 11	2015/08/14	21:14:56	-7:04.375	-88:27.712			Deployment	Abyss#0197 camera	DEA	4161.5
242-1_88-1	AUV 11	2015/08/14	23:18:00					Start mission	see Cruise Report	see Cruise Report	
242-1_88-1	AUV 11	2015/08/14	8:53:00					End mission	see Cruise Report	see Cruise Report	
242-1_88-1	AUV 11	2015/08/15	12:37:58	-7:05.194	-88:27.934			Recovery		DEA	4162.1
242-1_89-1	GC 4	2015/08/14	23:33:15	-7:04.564	-88:31.564	-7:04.562	-88:31.577	on ground		Ref west	4125.4
242-1_90-1	MUC 23	2015/08/15	3:40:10	-7:04.579	-88:31.546	-7:04.558	-88:31.566	on ground	edited from live observations	Ref west	4125
242-1_91-1	MUC 24	2015/08/15	6:55:58	-7:04.585	-88:31.561	-7:04.583	-88:31.558	on ground		Ref west	4127.2
242-1_92-1	MUC 25	2015/08/15	10:08:56	-7:04.560	-88:31.562	-7:04.563	-88:31.567	on ground		Ref west	4127.3
242-1_93-1	EBS 5	2015/08/15	13:43:03	-6:59.902	-88:30.764			Station start		NW of DEA	4142.1
242-1_93-1	EBS 5	2015/08/15	15:35:36	-7:00.954	-88:29.479	-7:00.477	-88:29.989	on ground	EBS on ground	NW of DEA	4064.5
242-1_93-1	EBS 5	2015/08/15	17:41:13	-7:01.541	-88:28.797	-7:01.129	-88:29.232	off ground	EBS off ground	NW of DEA	4050.8
242-1_93-1	EBS 5	2015/08/15	19:07:39	-7:01.536	-88:28.788			On deck		NW of DEA	4054
242-1_94-1	AUV 12	2015/08/15	20:55:17	-7:04.398	-88:27.604			Deployment	Abyss#0198; SSS and	DEA	4156.6

									camera		
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_94-1	AUV 12	2015/08/15	23:00:00					Start mission	see Cruise Report	see Cruise Report	
242-1_94-1	AUV 12	2015/08/16	10:25:00					End mission	see Cruise Report	see Cruise Report	
242-1_94-1	AUV 12	2015/08/16	14:30:26	-7:04.693	-88:29.425			Recovery		DEA	4150.3
242-1_95-1	BC 15	2015/08/15	23:27:49	-7:04.587	-88:31.555			on ground	no Posidonia signal	Ref west	4129.5
242-1_96-1	BC 16	2015/08/16	3:56:40	-7:04.480	-88:26.932	-7:04.482	-88:26.943	on ground		DEA (disturbed east)	4148
242-1_97-1	BoBo-Lander 3	2015/08/16	7:43:00	-7:07.422	-88:25.538			Deployment		Ref south	4162
242-1_98-1	BC 17	2015/08/16	12:00:05	-7:04.476	-88:26.921	-7:04.483	-88:26.919	on ground		DEA (disturbed east)	4173.9
242-1_99-1	DOS-Lander 4	2015/08/16	15:00:14	-7:04.268	-88:28.961			Deployment		DEA	4131.2
242-1_100-1	GC 5	2015/08/16	16:48:21	-7:04.341	-88:27.436	-7:04.342	-88:27.442	on ground		trough	4150.9
242-1_101-1	BC 18	2015/08/16	20:41:03	-7:04.485	-88:26.914	-7:04.477	-88:26.912	on ground		DEA (disturbed east)	4168.8
242-1_102-1	AUV 13	2015/08/16	23:07:33	-7:04.394	-88:27.603			Deployment	Abyss#0199 camera	DEA	4156.1
242-1_102-1	AUV 13	2015/08/17	1:25:00					Start mission	see Cruise Report	see Cruise Report	
242-1_102-1	AUV 13	2015/08/17	10:42:00					End mission	see Cruise Report	see Cruise Report	
242-1_102-1	AUV 13	2015/08/17	14:52:45	-7:06.474	-88:29.015			Recovery		DEA	4183.4
242-1_103-1	BC 19	2015/08/17	0:52:32	-7:04.478	-88:26.914	-7:04.483	-88:26.926	on ground		DEA (disturbed east)	4175.2
242-1_104-1	EBS 6	2015/08/17	3:32:41	-7:04.494	-88:34.423			Station start	EBS flipped over (failed)	Ref west	4155.5
242-1_104-1	EBS 6	2015/08/17	5:24:07	-7:05.515	-88:33.203	-7:05.065	-88:33.726	on ground	EBS on ground	Ref west	4123.8
242-1_104-1	EBS 6	2015/08/17	8:22:21	-7:06.512	-88:32.670	-7:05.888	-88:32.822	off ground	EBS off ground	Ref west	4084.1
242-1_104-1	EBS 6	2015/08/17	9:55:00	-7:06.513	-88:32.647			On deck		Ref west	4088.8

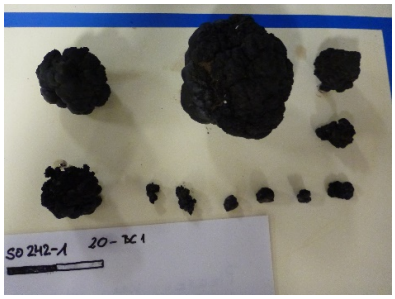
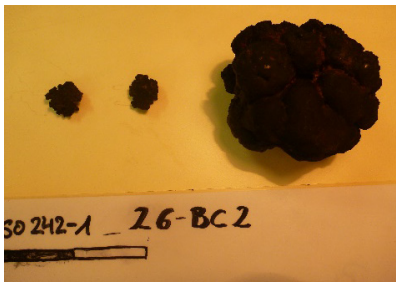
242-1_105-1	BC 20	2015/08/17	12:29:49	-7:04.482	-88:26.922	-7:04.484	-88:26.926	on ground		DEA (disturbed east)	4164.3
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_106-1	Amphi-Trap 5	2015/08/17	18:19:50	-6:55.112	-88:44.776			Deployment	no Posidonia signal	West of DISCOL	4268.7
242-1_106-1	Amphi-Trap 5	2015/08/19	20:19:55	-6:54.725	-88:44.859			Recovery			4237.1
242-1_107-1	AUV 14	2015/08/17	21:33:22	-7:04.605	-88:27.888			Deployment	Abyss#0200 camera	DEA (northwest)	4149.7
242-1_107-1	AUV 14	2015/08/17	23:52:00					Start mission	see Cruise Report	see Cruise Report	
242-1_107-1	AUV 14	2015/08/18	6:38:00					End mission	see Cruise Report	see Cruise Report	
242-1_107-1	AUV 14	2015/08/18	10:00:33	-7:02.602	-88:30.392			Recovery		DEA (northwest)	4123.4
242-1_108-1	MUC 26	2015/08/18	0:08:10	-7:04.539	-88:26.842	-7:04.483	-88:26.919	on ground		DEA (disturbed east)	4169.1
242-1_109-1	MUC 27	2015/08/18	4:04:03	-7:04.411	-88:26.833	-7:04.492	-88:26.836	on ground		DEA (disturbed east)	4161.5
242-1_110-1	MUC 28	2015/08/18	7:33:14	-7:04.479	-88:26.751	-7:04.449	-88:26.772	on ground		DEA (disturbed east)	4174.9
242-1_111-1	OFOS 3	2015/08/18	10:42:05	-7:03.550	-88:28.215			Station start		DEA	4137
242-1_111-1	OFOS 3	2015/08/18	12:44:38	-7:03.567	-88:28.192	-7:03.565	-88:28.203	on ground		DEA	4362.6
242-1_111-1	OFOS 3	2015/08/18	17:04:19	-7:04.495	-88:26.881	-7:04.464	-88:27.057	off ground		DEA	4162.8
242-1_111-1	OFOS 3	2015/08/18	18:27:32	-7:04.500	-88:26.896			On deck		DEA	4165.8
242-1_112-1	OFOS 4	2015/08/18	19:03:33	-7:02.313	-88:26.467			Station start		Seamount	4089.8
242-1_112-1	OFOS 4	2015/08/18	20:49:58	-7:02.307	-88:26.462	-7:02.300	-88:26.465	on ground	edited from live observations	Seamount	4058
242-1_112-1	OFOS 4	2015/08/19	0:06:00	-7:03.682	-88:25.961	-7:03.609	-88:25.962	off ground		Seamount	4161
242-1_112-1	OFOS 4	2015/08/19	1:30:09	-7:03.674	-88:25.959			On deck		Seamount	4158.4
242-1_113-1	AUV 15	2015/08/19	2:15:51	-7:04.386	-88:27.620			Deployment	Abyss#0201 camera	Ref south	4152.9

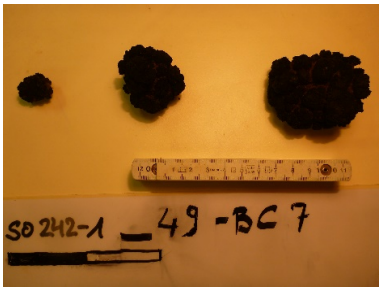
242-1_113-1	AUV 15	2015/08/19	4:41:00					Start mission	see Cruise Report	see Cruise Report	
242-1_113-1	AUV 15	2015/08/19	14:24:00					End mission	see Cruise Report	see Cruise Report	
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_113-1	AUV 15	2015/08/19	16:39:06	-7:07.357	-88:27.328			Recovery		Ref south	4137.1
242-1_114-1	MUC 29	2015/08/19	4:03:28	-7:04.451	-88:26.964	-7:04.449	-88:26.973	on ground		DEA (disturbed east)	4159.6
242-1_115-1	MUC 30	2015/08/19	7:24:05	-7:04.507	-88:27.042	-7:04.451	-88:26.981	on ground		DEA (disturbed east)	4157.3
242-1_116-1	P 70	2015/08/19	9:25:01	-7:04.519	-88:25.449			Profile start		East of DEA	4167
242-1_116-1	P 70	2015/08/19	15:33:30	-7:04.626	-88:27.881			Profile end		East of DEA	4126.8
242-1_117-1	EBS 7	2015/08/19	22:23:30	-7:04.414	-88:34.459			Station start	no Posidonia signal	Ref west	4155.7
242-1_117-1	EBS 7	2015/08/20	0:34:01	-7:05.531	-88:33.159			on ground	EBS on ground	Ref west	4168
242-1_117-1	EBS 7	2015/08/20	3:06:21	-7:06.344	-88:32.161			off ground	EBS off ground	Ref west	4133.3
242-1_117-1	EBS 7	2015/08/20	4:39:51	-7:06.339	-88:32.162			On deck		Ref west	4119.4
242-1_118-1	AUV 16	2015/08/20	5:52:45	-7:04.391	-88:27.603			Deployment	Abyss#0202; SBP test and SSS	Northeast of DEA	4156.2
242-1_118-1	AUV 16	2015/08/20	9:14:00					Start mission	see Cruise Report	see Cruise Report	
242-1_118-1	AUV 16	2015/08/20	22:30:00					End mission	see Cruise Report	see Cruise Report	
242-1_118-1	AUV 16	2015/08/21	1:55:19	-7:03.441	-88:25.450			Recovery		Northeast of DEA	4108.9
242-1_119-1	MUC 31	2015/08/20	8:37:35	-7:06.044	-88:24.830	-7:06.033	-88:24.826	on ground		Ref east	4204.1
242-1_120-1	BC 21	2015/08/20	12:28:25	-7:04.421	-88:27.845	-7:04.407	-88:27.852	on ground		DEA (heavily disturbed)	4144.3
242-1_121-1	BC 22	2015/08/20	15:31:19	-7:04.422	-88:27.850	-7:04.421	-88:27.862	on ground	edited from live observations	DEA (heavily disturbed)	4141
242-1_122-1	EBS 8	2015/08/20	18:18:41	-6:57.950	-88:27.112			Station start		N of DEA	4078
242-1_122-1	EBS 8	2015/08/20	20:12:19	-6:57.997	-88:25.324	-6:57.914	-88:25.955	on ground	EBS on ground	N of DEA	4081.6
242-1_122-1	EBS 8	2015/08/20	22:56:14	-6:58.021	-88:23.862	-6:57.963	-88:24.458	off ground	EBS off ground	N of DEA	4050.7

242-1_122-1	EBS 8	2015/08/21	0:41:00	-6:58.021	-88:23.861			On deck		N of DEA	4049.9
242-1_123-1	GC 6	2015/08/21	3:48:48	-7:06.049	-88:24.836	-7:06.045	-88:24.848	on ground	no Posidonia signal for most of the deployment	Ref east	4216.8
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_124-1	BC 23	2015/08/21	7:22:13	-7:04.419	-88:27.847	-7:04.411	-88:27.848	on ground		DEA (heavily disturbed)	4144.6
242-1_125-1	AUV 17	2015/08/21	9:08:46	-7:04.398	-88:27.621			Deployment	Abyss#203; SBP and SSS	Northeast of DEA	4157.7
242-1_125-1	AUV 17	2015/08/21	13:14:00					Start mission	see Cruise Report	see Cruise Report	
242-1_125-1	AUV 17	2015/08/21	23:33:00					End mission	see Cruise Report	see Cruise Report	
242-1_125-1	AUV 17	2015/08/22	2:27:01	-7:05.351	-88:23.936			Recovery		Northeast of DEA	4288
242-1_126-1	EBS 9	2015/08/21	11:07:09	-7:08.871	-88:22.592			Station start		Southeast of DISCOL	4119.4
242-1_126-1	EBS 9	2015/08/21	13:09:00	-7:07.183	-88:22.724	-7:07.823	-88:22.674	on ground	EBS on ground	Southeast of DISCOL	4277.4
242-1_126-1	EBS 9	2015/08/21	15:31:56	-7:06.234	-88:22.787	-7:06.786	-88:22.756	off ground	EBS off ground	Southeast of DISCOL	4280
242-1_126-1	EBS 9	2015/08/21	17:06:44	-7:06.242	-88:22.798			On deck		Southeast of DISCOL	4275.7
242-1_127-1	BC 24	2015/08/21	20:07:01	-7:04.410	-88:27.839	-7:04.411	-88:27.846	on ground		DEA (heavily disturbed)	4146.9
242-1_128-1	BC 25	2015/08/21	23:21:38	-7:04.420	-88:27.845	-7:04.411	-88:27.843	on ground		DEA (heavily disturbed)	4146.4
242-1_129-1	BC 26	2015/08/22	4:21:40	-7:03.364	-88:26.015	-7:03.373	-88:26.026	on ground		Small crater	4144.3
242-1_130-1	MUC 32	2015/08/22	8:05:44	-7:06.043	-88:24.830	-7:06.036	-88:24.837	on ground		Ref east	4204.1
242-1_131-1	MUC 33	2015/08/22	12:15:06	-7:06.042	-88:24.835	-7:06.034	-88:24.835	on ground		Ref east	4203.8
242-1_132-1	GC 7	2015/08/22	14:56:53	-7:03.363	-88:26.020	-7:03.369	-88:26.031	on ground		Small crater	4151.7
242-1_133-1	LBL Recovery	2015/08/22	17:10:02	-7:03.167	-88:27.055			On deck		DEA	4109.9
242-1_133-1	LBL Recovery	2015/08/22	17:54:13	-7:03.131	-88:28.898			On deck		DEA	4185.5
242-1_133-1	LBL Recovery	2015/08/22	18:50:52	-7:05.176	-88:28.791			On deck		DEA	4167

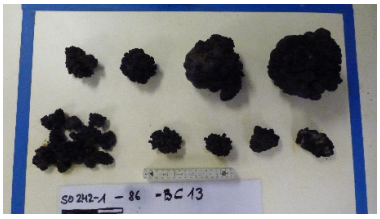
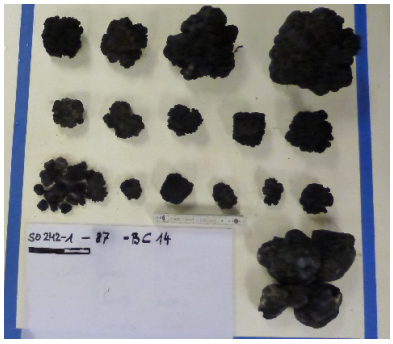
242-1_133-1	LBL Recovery					-7:05.349	-88:26.766	Information	Transponder did not release	DEA	
242-1_134-1	OFOS 5	2015/08/22	20:07:50	-7:04.827	-88:28.396			Station start		DEA to Eastern Basin	4148
Station Number	**Device**	**Date**	**Time (UTC)**	**Ship Position**		**Device Position**		**Action**	**Comment**	**Area**	**Water Depth**
		[yyyy/mm/dd]	**[hh:mm:ss]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**	**Latitude [dd:mm.mmm]**	**Longitude [dd:mm.mmm]**				**[m]**
242-1_134-1	OFOS 5	2015/08/22	21:40:17	-7:04.835	-88:28.389	-7:04.828	-88:28.393	on ground		DEA to Eastern Basin	4147
242-1_134-1	OFOS 5	2015/08/23	4:06:00	-7:04.402	-88:25.411	-7:04.546	-88:25.634	off ground		DEA to Eastern Basin	4190.3
242-1_134-1	OFOS 5	2015/08/23	5:32:29	-7:04.404	-88:25.420			On deck		DEA to Eastern Basin	4190.7
242-1_135-1	OFOS 6	2015/08/23	6:23:47	-7:03.052	-88:26.656			Station start		Seamount	4067.1
242-1_135-1	OFOS 6	2015/08/23	7:51:42	-7:03.041	-88:26.591	-7:03.057	-88:26.634	on ground		Seamount	4081.3
242-1_135-1	OFOS 6	2015/08/23	11:01:56	-7:02.925	-88:25.427	-7:02.907	-88:25.447	off ground		Seamount	4122
242-1_135-1	OFOS 6	2015/08/23	12:21:34	-7:02.923	-88:25.428			On deck		Seamount	4121
242-1_136-1	P 70 / EM 122	2015/08/23	13:21:21	-7:09.800	-88:20.563			station start		Transit	4153.7
242-1_136-1	P 70 / EM 122	2015/08/24	8:45:10	-5:15.743	-84:44.912			station end	end at 200nmi zone	Transit	3946.6

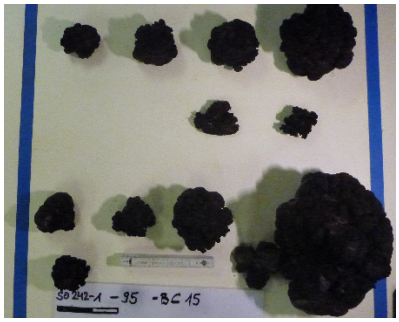
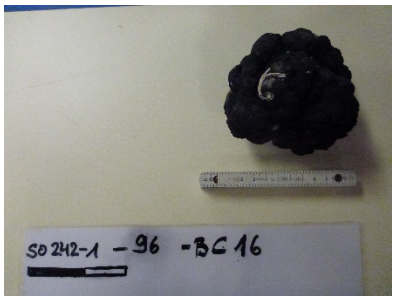
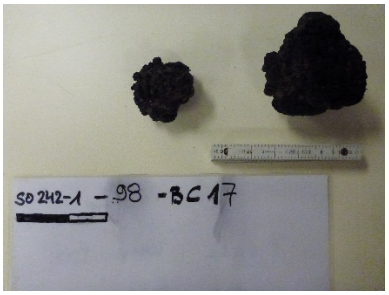
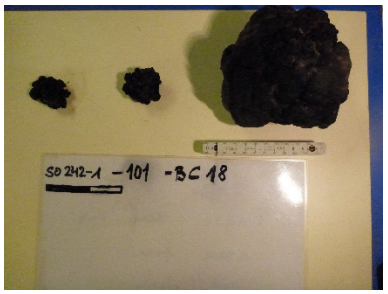
9.2 Box Corer
9.2.1 BC images

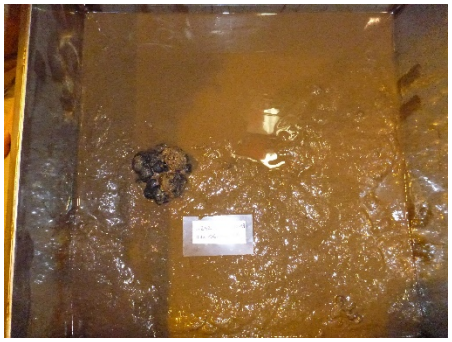
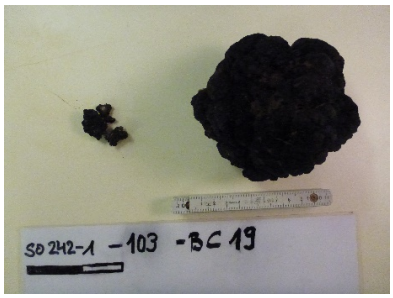
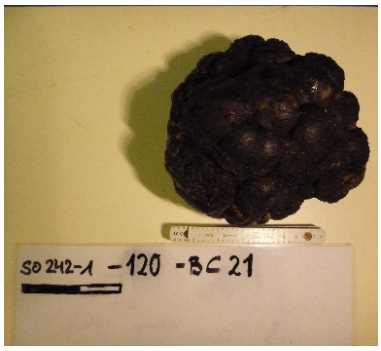
Station	Box-core sample	Nodule sample
SO242-20-BC1 **Reference area 1** **Latitude: -7:07.531** **Longitude: -88:27.033** **Depth: 4161.8 m** **Lowering speed:0.3 kn**		
SO242-26-BC2 **Reference area 1** **Latitude: -7:07.536** **Longitude: -88:27.002** **Depth: 4163.6m** **Lowering speed:0.3 kn**		
SO242-27-BC3 **Reference area 1** **Latitude: -7:07.548** **Longitude: -88:27.029** **Depth: 4139.4m** **Lowering speed:0.3 kn** **Description: brown sediment until 10 cm**		
SO242-31-BC4 **Reference area 1** **Latitude: -7:7.5765** **Longitude: -88:27.0148** **Depth: 4167m** **Lowering speed:0.4 kn** **Description: brown sediment until 10 cm**		

SO242-32-BC5 **Reference area 1** Latitude: -7:7.5396 Longitude: -88:27.0389 Depth: 4162.1m Lowering speed:1.1 kn Description: Brown sediment until 10 cm		
SO242-48-BC6 **DEA** Latitude: -7:04.413 Longitude: -88:27.839 Depth: 4144.4m Lowering speed: 0.2 kn Description: 3-6 cmof water Disturbed;1Nodule at 2 cm		
SO242-49-BC7 **DEA** Latitude: -7:04.412 Longitude: -88:27.839 Depth: 4142.4m Lowering speed: 0.1 kn Description: 3-6 cmof water Transitional Disturbed/Undisturbed		
SO242-52-BC8 **DEA** Latitude: -7:04.411 Longitude: -88:27.844 Depth: 4145.6 m Lowering speed: 0.5 kn Description: Disturbed. 13-16 cm of water. Nodules between 3-5 cm and after 10 cm		

SO242-53-BC9 **DEA** Latitude: -7:04.423 Longitude: -88:27.879 Depth: 4146.3 m Lowering speed: 0.7 kn Description: 16 cm of water. Nodules at bottom; Transitional Disturbed/ Undisturbed		
SO242-54-BC10 **DEA** Latitude: -7:04.419 Longitude: -88:27.844 Depth: 4149.8 m Lowering speed: kn Description: 26 cm of water. 1 nodule with epifauna, only this bc from this area had a nodule at surface. Does not seem disturbed		
SO242-77-BC11 **Reference West** Latitude: -7:04.574 Longitude: -88:31.577 Depth: 4130.5m Lowering speed: 0.8 kn Description: 30 cm of water, 20 cm of sediment. Nodules at surface; two with strong smell; 2 big nodules after 10 cm		

SO242-78-BC12 **Reference West** Latitude: -7:04.554 Longitude: -88:31.564 Depth: 4131.2m Lowering speed: 0.9 kn Description: 16 cm of water. Nodules at surface		
SO242-86-BC13 **Reference West** Latitude: -7:04.627 Longitude: -88:31.559 Depth: 4129.5m Lowering speed: 0.4 kn Description: 19 cm of water, 10 first cm with brown fluffy sediment. nodules at surface with epifauna: coral scyphozoa		
SO242-87-BC14 **Reference West** Latitude: -7:04.604 Longitude: -88:31.563 Depth: 4123.4m Lowering speed: kn Description: 21 cm of water. nodules at surface with epifauna, nodules after 10 cm		

SO242-95-BC15 **Reference West** Latitude: -7:04.587 Longitude: -88:31.555 (position of ship) Depth: 4129.5m Lowering speed: 0.3 kn Description: 21 cm of water. Nodules at surface with epifauna, nodules after 10 cm		
SO242-96-BC16 **DEA (2)** Latitude: -7:04.482 Longitude: -88:26.943 Depth: Lowering speed: Description: 15 cm of water. 1 nodule at surface; partially disturbed		
SO242-98-BC17 **DEA (2)** Latitude: -7:04.483 Longitude: -88:26.919 Depth: 4173.9m Lowering speed: 0.3 Description: 19 cm of water. 1 nodule at surface; 1 nodule after 10 cm		
SO242-101-BC18 **DEA (2)** Latitude: -7:04.477 Longitude: -88:26.912 Depth: 4168.8m Lowering speed: 0.8 Description: 14 cm of water 1 nodule small (3-5 cm); 1 nodule big (5-10 cm)		

SO242-103-BC19 **DEA (2)** Latitude: -7:04.483 Longitude: -88:26.926 Depth: 4175.2m Lowering speed: 1.5 Description: 19 cm of water. 1 nodule at surface		
SO242-105-BC20 **DEA (2)** Latitude: -7:04.484 Longitude: -88:26.926 Depth: 4164.3m Lowering speed: 0.4 Description: 12 cm of water. Nodules after 5 cm disturbed.		
SO242-120-BC21 **DEA** Latitude:7:04.407 Longitude: -88:27.852 Depth: 4144.3 Lowering speed: 0.6 Description: 16-26 cm; disturbed. 1 nodule between 3-10 cm		
SO242-121-BC22 **DEA** Latitude: -7:04.421 Longitude: -88:27.862 Depth: 4142 m (edited from live observations / entry in the station book is missing Lowering speed: 0.6	empty	empty

SO242-124-BC23 **DEA** Latitude: -7:04.411 Longitude: -88:27.848 Depth: 4144.6 Lowering speed: 0.4 Description: 5-19 cm; disturbed		
SO242-127-BC24 **DEA** Latitude: -7:04.411 Longitude: -88:27.846 Depth: 4146.9 Lowering speed: 0.4 Description: 1 nodule after 10 cm		
SO242-128-BC25 **DEA** Latitude: -7:04.420 Longitude: -88:27.845 (position of the boat) Depth: 4146.4 Lowering speed: ? Description: 3-5 cm; disturbed. Nodule after 5 cm		
SO242-129-BC26 Latitude: -7:03.364 Longitude: -88:26.015 (position of the boat) Depth: 4144.3 Description: Not quantitative. Subsampled for geology (3 liners) and ostracoda diversity (1 liner) studies		

9.2.2 BC nodule recovery

Station Record on BC - Nodules Recovery

St. No.	Lat. S	Long. W	W.depth m	No.	Width cm	Height cm	Weight kg	Remarks
20 BC01	7° 7,530′	88° 27,033′	4162,3	1	13,0	11,5	1,750	big
				2	7,5	7,0	0,288	
				3	6,0	4,5	0,126	
				4	5,5	5,0	0,104	
				5	4,5	3,8	0,038	Plus 6 small nodules < 20 gr
							2,306	**Total weight**
26 BC02	7° 7,536′	88° 27,002′	4163,6	1	9,5	8,5	0,638	Plus 2 small nodules < 20 gr
							0,668	**Total weight**
27 BC03	7° 7,551′	88° 27,035′	4166,6	1	12,1	11,1	1,155	big
				2	12,0	11,8	1,400	big
				3	10,2	10,0	0,780	big
				4	8,6	8,8	0,525	big
				5	3,0	2,6	0,028	
				6	3,4	2,4	0,025	
				7	3,5	1,8	0,023	
				8	3,5	1,7	0,020	
				9	3,8	3,0	0,028	
				10	4,2	3,3	0,030	Plus 1 small nodule < 20 gr
							3,991	**Total weight**
31 BC 04	7° 7,556′	88° 27,001′	4167,0	1	10,2	10,0	0,838	big
				2	7,5	7,0	0,295	Plus 2 small nodules < 20 gr
							1,133	**Total weight**
32 BC05	7° 7,528′	88° 27,024′	4162,1	1	12,4	10,9	1,695	deep nodule
				2	12,0	10,4	1,312	deep nodule
				3	10,5	10,8	0,956	
				4	9,3	7,7	0,571	
				5	4,4	3,8	0,041	
				6	3,5	2,6	0,021	Plus 2 small nodules < 20 gr
							4,596	**Total weight**
48 BC06	7° 4,409′	88° 27,842′	4146,3	1	8,2	7,5	0,445	from 20 cm sediment depth
							0,445	**Total weight**
49 BC07	7° 4,412′	88° 27,839′	4142,4	1	6,0	4,2	0,085	
				2	3,7	3,7	0,047	Plus 2 small nodules < 20 gr
							0,132	**Total**

								weight
52 BC08	7° 4,404′	88° 27,835′	4145,6	1	12,2	14,0	2,365	
				2	10,7	8,8	0,806	
				3	8,0	7,3	0,460	
				4	5,7	4,7	0,168	
				5	6,0	4,0	0,122	
				6	5,8	4,8	0,126	
				7	2,8	2,2	0,049	Plus several nodules < 20 gr
							4,096	**Total weight**
53 BC09	7° 4,414′	88° 27,864′	4146,3	1	10,8	6,7	0,480	
				2	9,5	5,1	0,296	No. 1 and 2 broken lesnod
				3	5,4	5,1	0,117	
							0,893	**Total weight**
54 BC10	7° 4,395′	88° 27,846′	4149,8	1	10,3	10,5	1,155	
							1,155	**Total weight**
77 BC11	7° 4,574′	88° 27,567′	4130,5	1	16,5	16,1	3,600	From 20 cm sed. depth
				2	14,2	12,0	1,652	
				3	9,5	8,7	0,477	
				4	8,8	7,6	0,393	
				5	7,6	6,6	0,235	
				6	6,7	6,7	0,198	
				7	5,4	4,6	0,115	
				8	5,6	3,3	0,094	
				9	4,4	3,8	0,075	
				10	4,8	3,7	0,066	
				11	3,6	3,0	0,052	Plus several nodules < 20 gr
							7,107	**Total weight**
78 BC12	7° 4,551′	88° 31,559′	4131,2	1	12,5	12,0	1,595	
				2	10,8	7,4	0,589	
				3	7,7	6,8	0,290	
				4	5,9	4,0	0,135	
				5	5,1	4,2	0,124	
				6	5,3	3,7	0,083	
				7	5,0	2,1	0,057	
				8	5,1	1,8	0,065	About 15 nodules < 30 gr
							3,088	**Total weight**
86 BC13	7° 4,623′	88° 31,538′	4119,8	1	10,6	9,0	0,835	
				2	8,7	7,1	0,440	
				3	5,0	4,4	0,085	
				4	5,2	3,9	0,075	
				5	5,8	3,7	0,067	
				6	4,7	3,5	0,040	
				7	4,0	3,3	0,038	
				8	4,7	3,2	0,042	About 12 nodules < 20 gr
							1,622	**Total weight**

87 BC14	7° 4,612’	88° 31,559’	4123,4	1	12,2	10,4	1,366	
				2	10,5	9,6	0,635	
				3	7,4	5,7	0,315	
				4	6,2	5,5	0,260	
				5	6,0	5,3	0,238	
				6	4,8	4,5	0,166	
				7	4,8	3,5	0,105	
				8	5,7	2,8	0.045	
				9	4,6	2,8	0,108	
				10	4,3	4,0	0,098	
				11	3,8	2,4	0,045	1 broken subsurface nodule 1,095 gr
				12	4,3	3,5	0,115	About 15 nodules < 20
							4,594	**Total weight**
95 BC15	7° 4,587’	88° 31,555’	4129,5	1	10,5	11,2	0,716	surf. nodules
				2	6,8	6,2	0,215	
				3	6,4	5,9	0,172	
				4	5,3	4,5	0,090	
				5	3,0	3,2	0,048	
				6	19,4	14,0	3,255	nodules from 10 – 20 cm
				7	7,8	6,9	0,370	
				8	5,7	4,8	0,092	
				9	4,8	4,5	0,076	
							5,034	**Total weight**
96 BC16	7° 4,480’	88° 26,932’	4163,8	1	9,8	8,0	0,880	1 surface nodule only
							0,880	**Total weight**
98 BC17	7° 4,476’	88° 26,921’	4173,9	1	8,4	7,1	0,447	
				2	5,4	4,6	0.164	No disturbance
101 BC18	7° 4,485’	88° 26,914’	4173,9	1	11,8	11,0	1,585	Slightly disturbed
				2	4,0	3,7	0,076	
							1,661	**Total weight**
103 BC19	7° 4,478’	88° 26,914’	4165,4	1	11,8	12,0	1,195	Some small pieces < 20 gr
							1,195	**Total weight**
105 BC20	7° 4,482’	88° 26,922’	4164,3	1	7,4	6,1	0,305	Slightly disturbed
				2	6,0	4,6	0,105	
				3	5,0	3,8	0,088	Some small pieces < 20 gr
							0,498	**Total weight**
120 BC21	7° 4,421’	88° 27,845’	4142,6	1	14,0	12,2	**2,520**	**Total weight**
121 BC22	7° 4,429’	88° 27,850’	4143,4					BC failed
124 BC23	7° 4,419’	88° 27,847’	4144,6	1	10,8	10,7	1,488	Completely

								disturbed
				2	7,2	7,8	0,275	
							1,763	**Total weight**
127 BC24	7° 4,410’	88° 27,839’	4144,9	1	14,5	12,2	**2,275**	**Total weight**
128 BC25	7° 4,420’	88° 27,845’	4146,4	1	11,7	11,6	1,759	Completely disturbed
				2	7,8	7,0	0,362	
				3	4,0	3,5	0,044	
							2,165	**Total weight**
Total nodule weight of all stations							**53,818**	

9.3 Shear strength data of BC sediment

Shear strength data in box core samples (D10 = 10cm core depth; 20=20c, 30=30cm, 40=40cm).

St. No.	Lat. S	Long. W	Water depth m	D10 kPa	D20 kPa	D30 kPa	D40 kPa	Remarks
20 BC01	7° 7,530'	88° 27,033'	4162,3	4,0	7,0	12,0	12,5	BC full
				3,5	4,0	8,0	8,0	
26 BC02	7° 7,536'	88° 27,002'	4163,6	1,0	5,0	9,0	--	BC 4/5 full
				2,0	7,0	11,0	--	
27 BC03	7° 7,551'	88° 27,035'	4166,6	2,5	9,5	10,0	--	BC 4/5 full
				4,0	7,0	11,0	--	
31 BC 04	7° 7,556'	88° 27,001'	4167,0	3,5	11,0	10,5	--	BC 4/5 full
				3,0	8,0	8,5	--	
32 BC05	7° 7,528'	88° 27,024'	4162,1	2,0	6,0	7,5	--	BC 4/5 full
				2,5	6,5	10,0	--	
48 BC06	7° 4,409'	88° 27,842'	4146,3	1,0	4,0	9,0	--	BC 4/5 full
				1,0	8,5	10,0	--	
49 BC07	7° 4,412'	88° 27,839'	4142,4	3,5	7,0	--	--	BC 3/5 full
				3,5	7,0	--	--	
				3,5	6,5	--	--	
52 BC08	7° 4,404'	88° 27,835'	4145,6	1,5	3,0	8,5	9,5	BC full
				1,0	4,0	9,0	11,5	Many nodules
53 BC09	7° 4,414'	88° 27,864'	4146,3	2,5	3,0	--	--	BC 3/5 full
				1,5	5,5	7,0	--	
54 BC10	7° 4,395'	88° 27,846'	4149,8	3,5	8,0	9,0	--	BC 4/5 full
				3,0	8,5	7,0	--	
77 BC11	7° 4,574'	88° 27,567'	4130,5	3,5	8,5	--	--	BC 3/5 full
				3,0	11,0	--	--	
78 BC12	7° 4,551'	88° 31,559'	4131,2	2,5	7,0	8,0	--	BC 4/5 full
				3,0	8,0	10,0	--	
86 BC13	7° 4,623'	88° 31,538'	4119,8	3,0	8,5	10,0	--	BC 4/5 full
				5,0	8,0	9,0	--	
87 BC14	7° 4,612'	88° 31,559'	4123,4	4,0	9,5	8,5	--	BC 4/5 full
				3,0	8,5	11,5		
95 BC15	7° 4,587'	88° 31,555'	4129,5	3,0	6,0	10,5	--	
				1,5	6,5	7,5	--	BC 4/5 full
96 BC16	7° 4,480'	88° 26,932'	4163,8	3,5	7,0	7,5	7,5	
				3,5	7,0	10,0	12,0	Slightly disturbed
98 BC17	7° 4,476'	88° 26,921'	4173,9	2,0	6,0	9,0	--	Not disturbed
				2,0	7,5	8,5	--	
101 BC18	7° 4,485'	88° 26,914'	4168,8	3,0	8,0	9,0	11,5	Slightly disturbed
				2,5	6,0	6,0	9,5	
103 BC19	7° 4,478'	88° 26,914'	4165,4	2,0	7,0	7,5	--	
				2,0	6,0	8,0	--	
105 BC20	7° 4,482'	88° 26,922'	4164,3	3,0	5,0	9,0	7,0	Slightly disturbed
				1,5	5,0	8,0	12,0	
				2,5	6,0	8,5	9,0	
120 BC21	7° 4,421'	88° 27,845'	4142,6	1,0	9,0	13,0	--	Heavily disturbed sediment core
				3,0	8,5	12,5	--	
121 BC22	7° 4,429'	88° 27,847'	4143,6					Sampling failed; BC was not closed
124 BC23	7° 4,419'	88° 27,847'	4143,6	0,5	4,0	4,5	10,0	Completely disturbed
				1,0	5,5	9,0	8,0	
127 BC24	7° 4,410'	88° 27,839'	4144,9	1,5	6,0	10,0	12,5	Completely disturbed
				2,5	7,0	11,0	17,0	
128 BC25	7° 4,420'	88° 27,845'	4146,4	1,0	1,0	6,5	11,0	Completely disturbed
				1,0	3,0	7,0	11,0	

9.4 GC and MUC descriptions

M. Haeckel, H. de Stigter

Following the photographs and descriptions of all cores retrieved by MUC and GC deployments and analyzed by the geochemistry group are compiled. Coordinates of the individual cores are given in Table 7.16.2 and Figure 8.3.1 shows the coring sites on bathymetric and sidescan sonar backscatter maps. The cores are ordered by study sites according to Chapter 8.3.

9.4.1 Southern reference site with nodules

34 MUC 6 (0 – 29 cm)

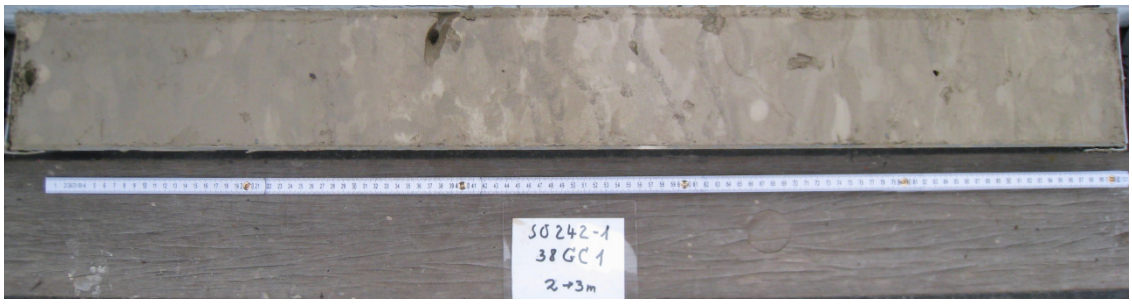
left core: used for O_2 micro-profiling
right core: used for porewater squeezing (contained a nodule at the sediment surface)

38 GC1 0 – 917 cm

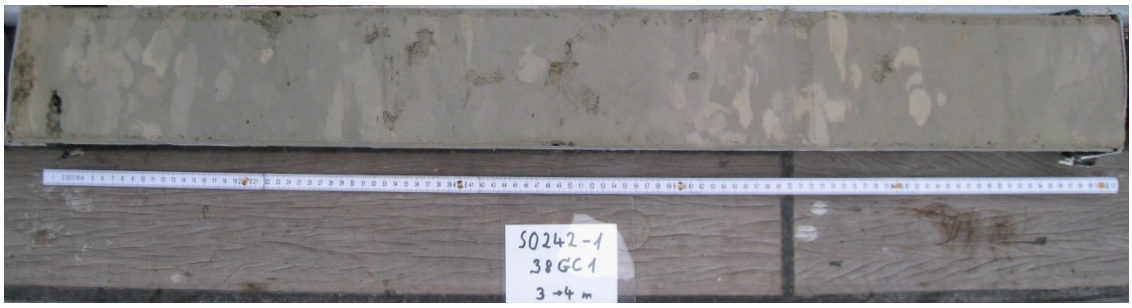
0-31 (nodule at the surface)

31-131

131-231

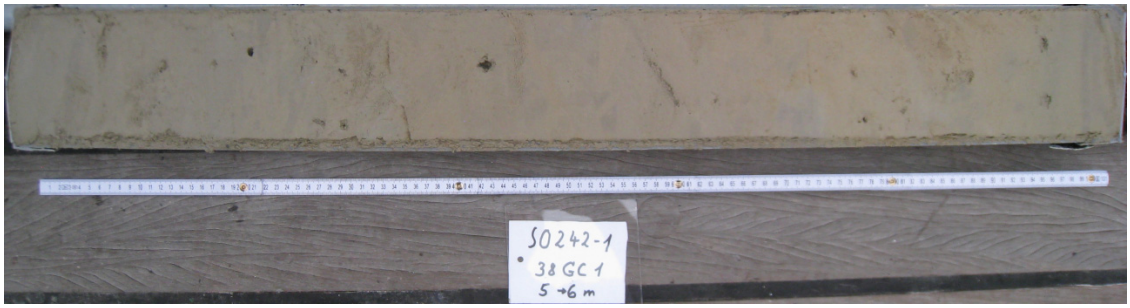


231-331



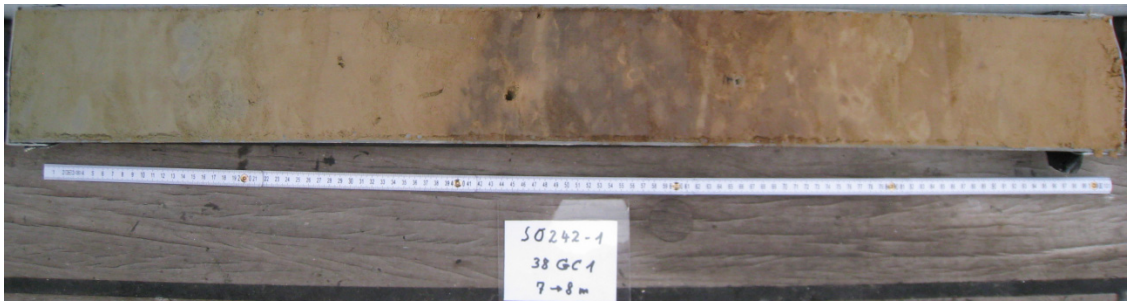
331-431

431-531



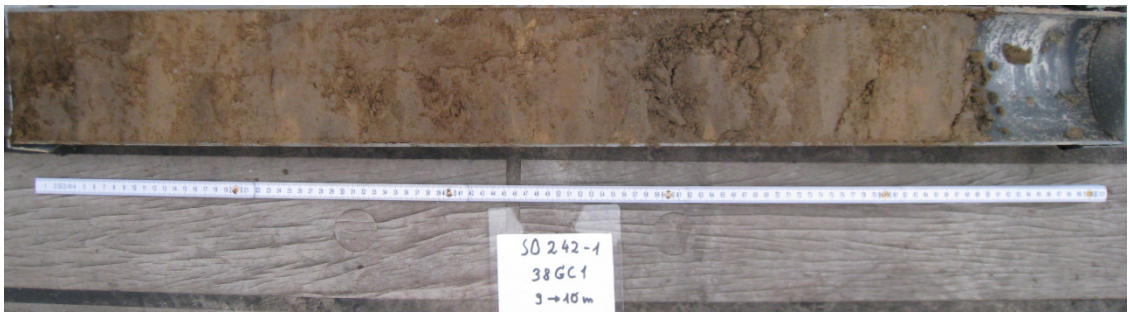
531-631

631-731



731-831

831-917

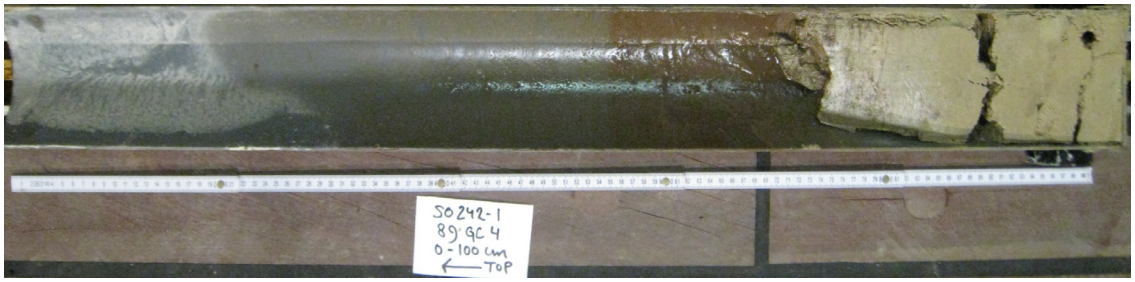


9.4.2 Western reference site

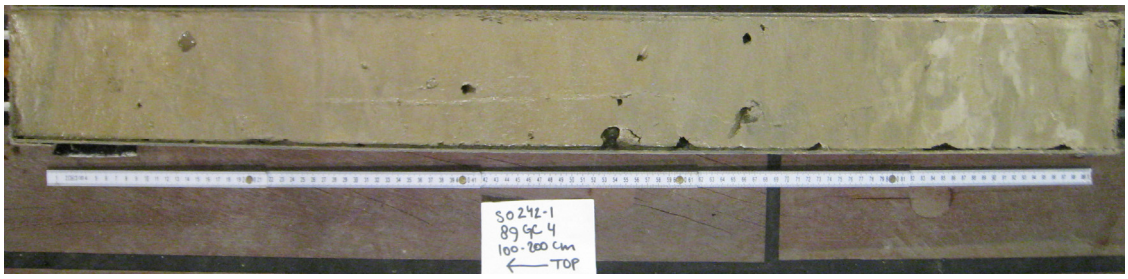
80 MUC 22 (0 – 22.5 cm)

89 GC 4 (0 – 958 cm)

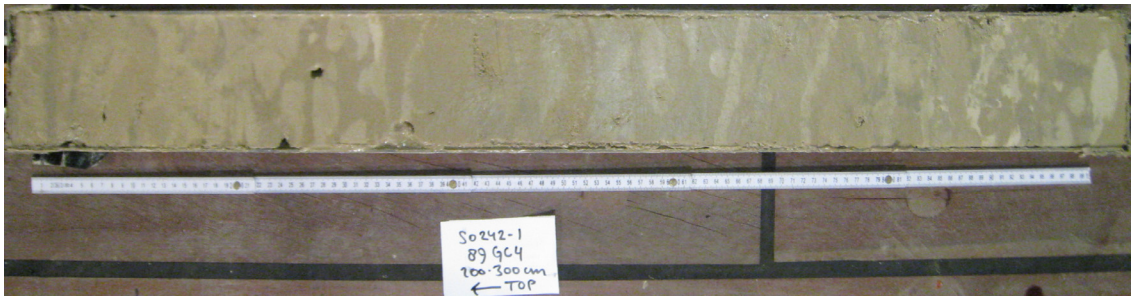
0-41



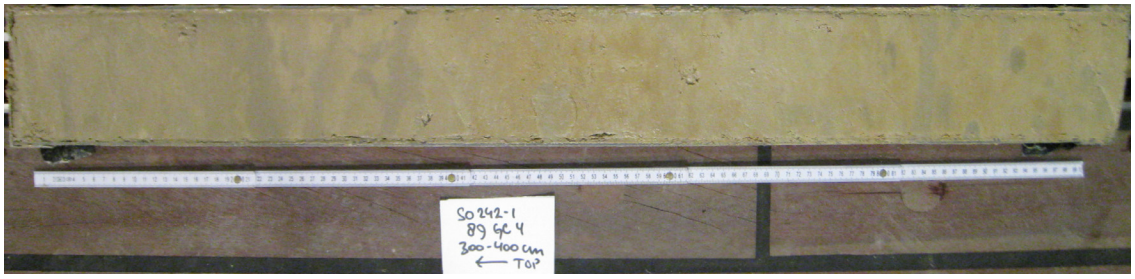
41-141



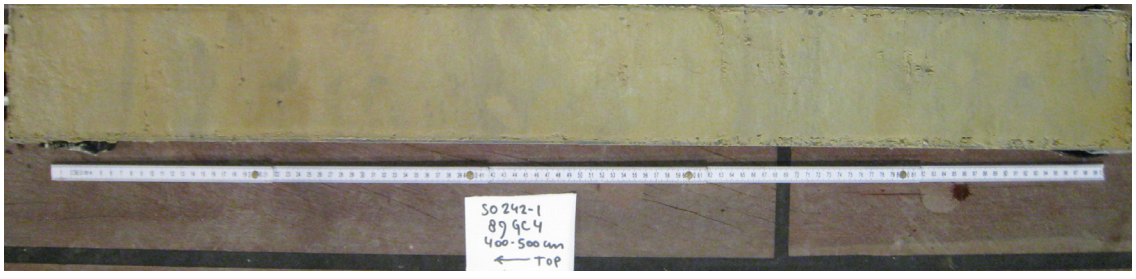
141-241



241-341



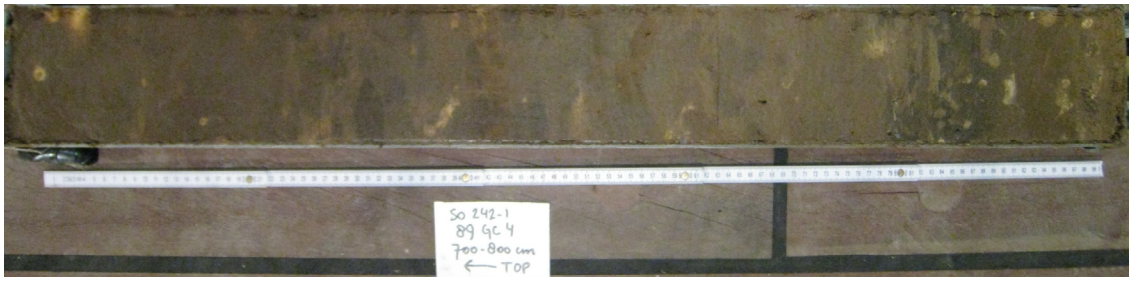
341-441



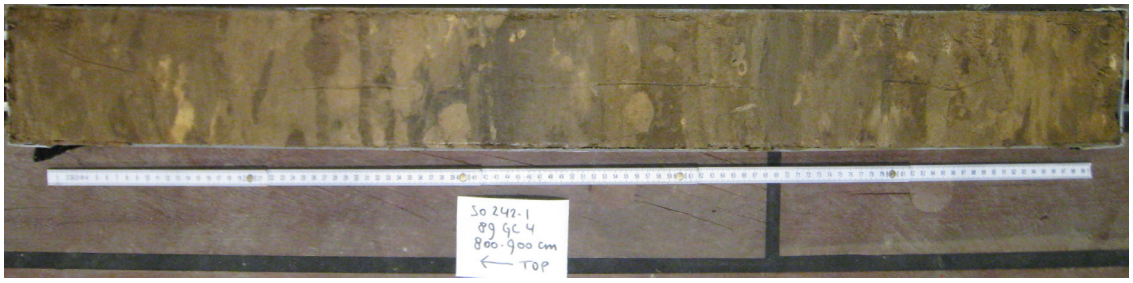
441-541

541-641

641-741



741-841



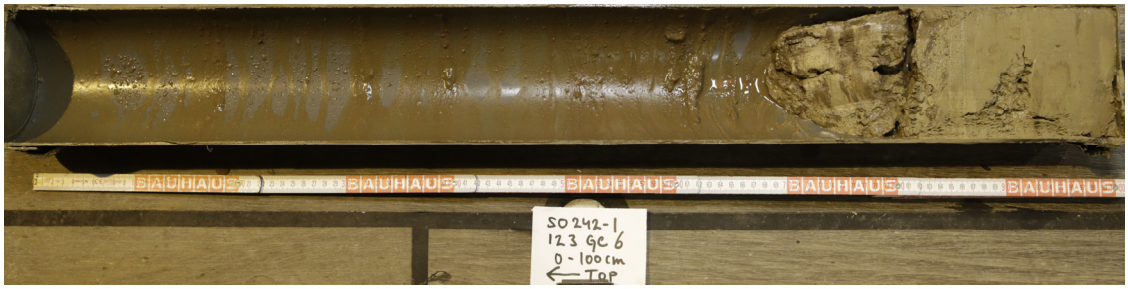
841-928

9.2.3 Eastern reference site

#119 MUC 31 (0 – 33 cm)

#123 GC 6 (0 – 921 cm)

0-35



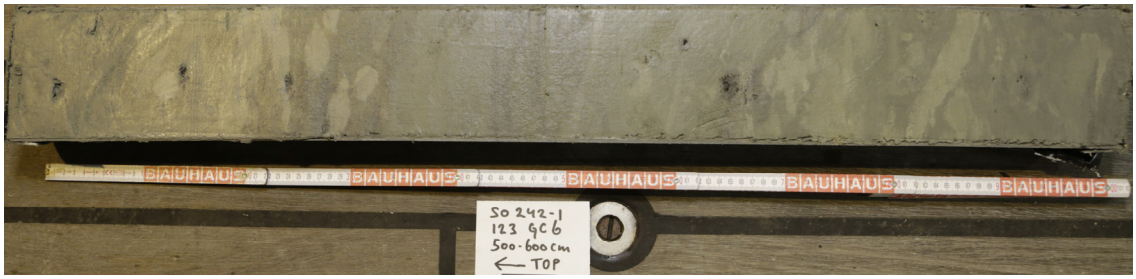
35-135

135-235

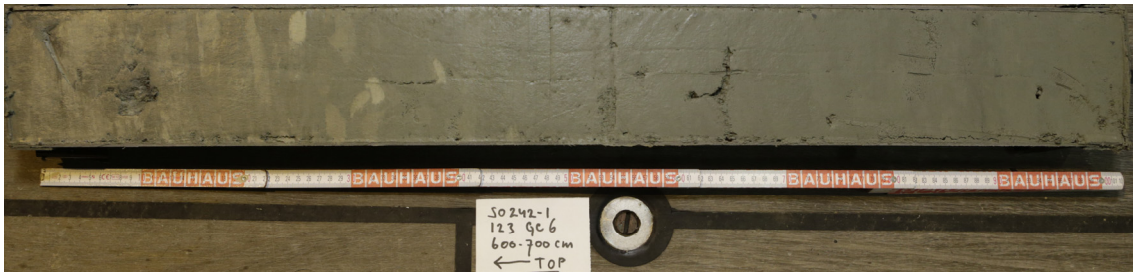
235-336

336-436

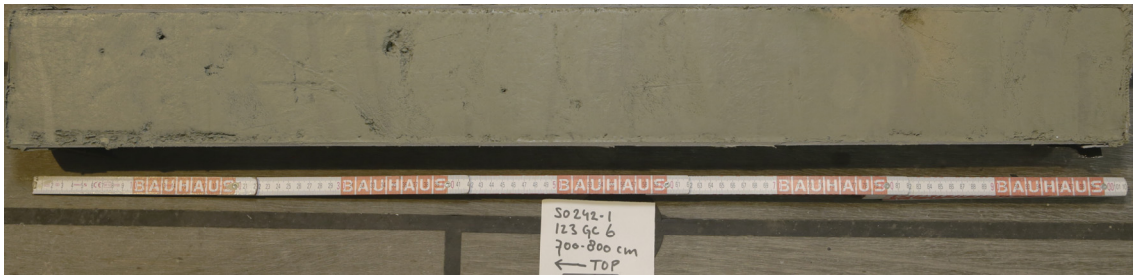
436-536



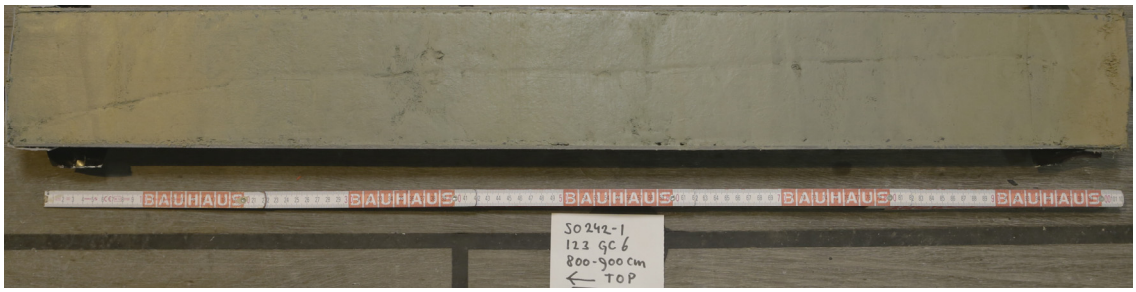
536-636



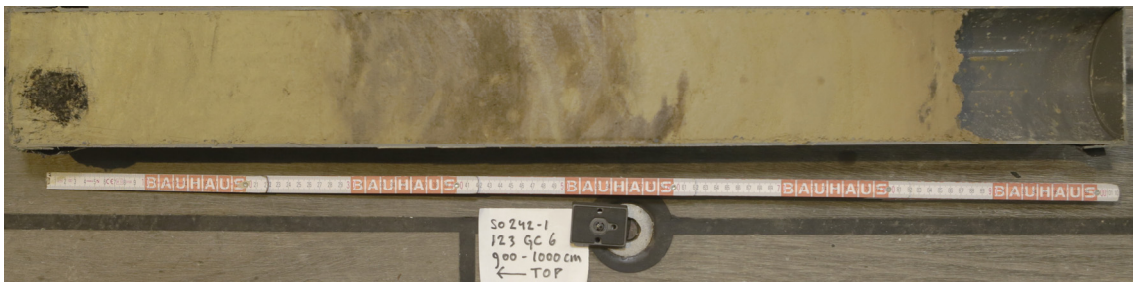
636-736



736-836



836-921



9.4.4 DEA plough marks

Western site (inside plough mark) **#56 TV-MUC 12** (0 – 40 / 28 cm)

left core: used for O_2 micro-profiling

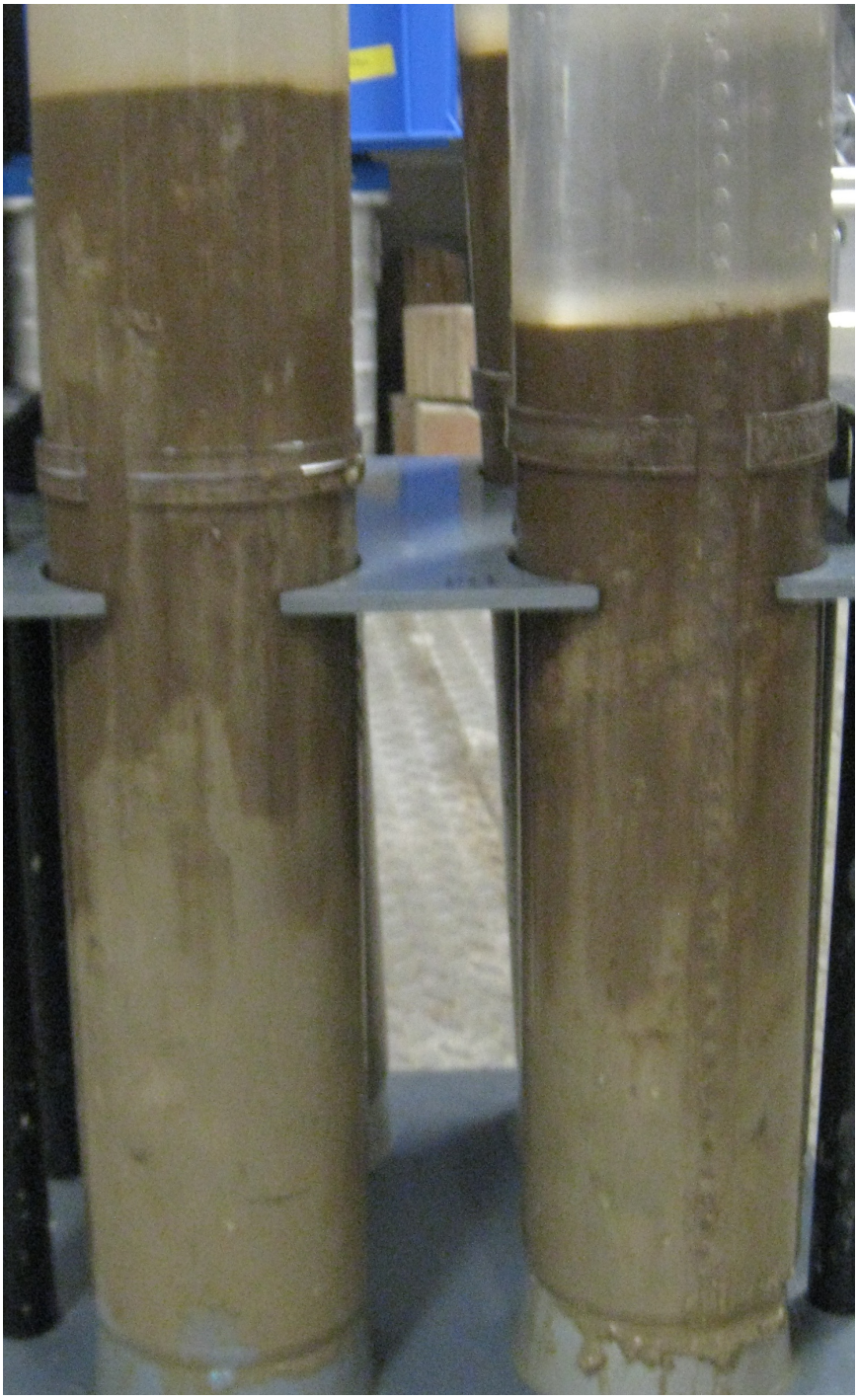
right core: used for Rhizon porewater sampling

Western site (next to plough mark) **#61 TV-MUC 13** (0 – 35 cm)

Western site (next to plough mark) **#70 TV-MUC 17** (0 – 26 cm)

Eastern site (inside plough mark with resettled sediment)

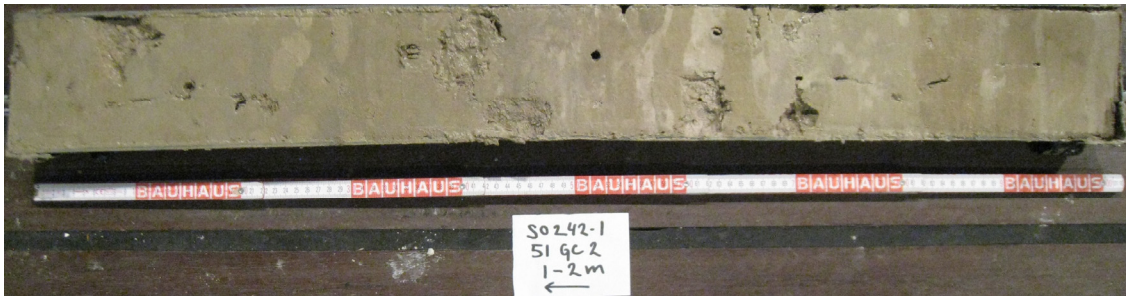
#128 TV-MUC 26 (0 – 40 cm)



Western site **#51 GC 2** (0 – 978 cm)

0-80

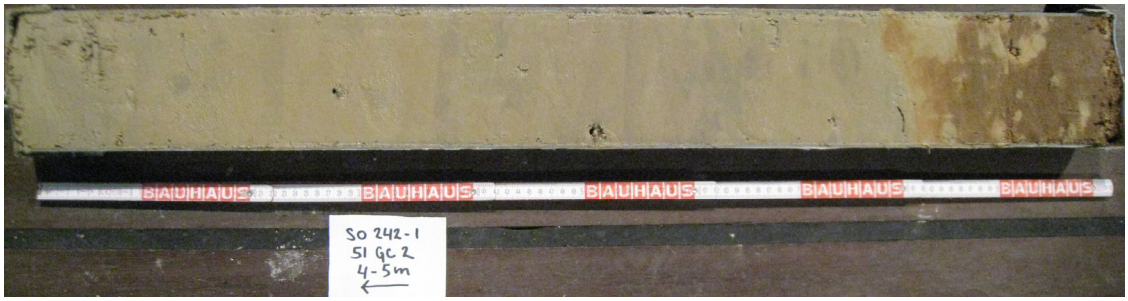
80-178



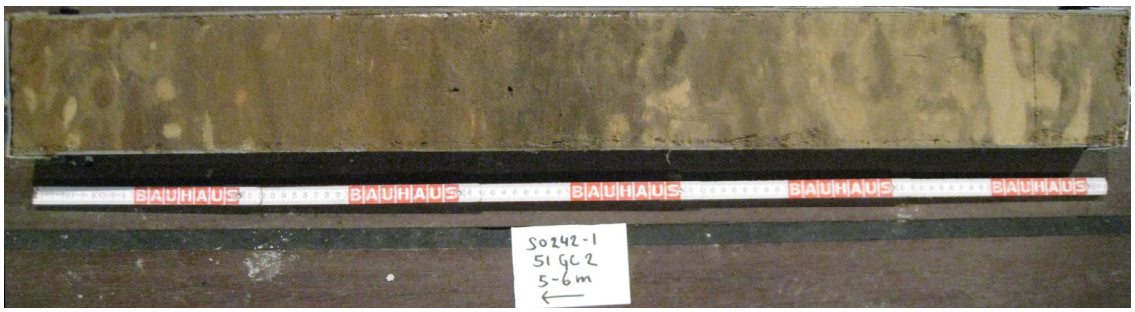
178-278

278-378

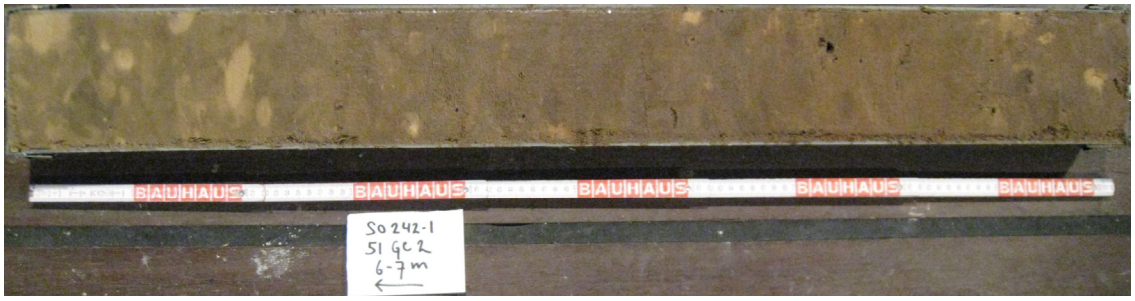
378-478



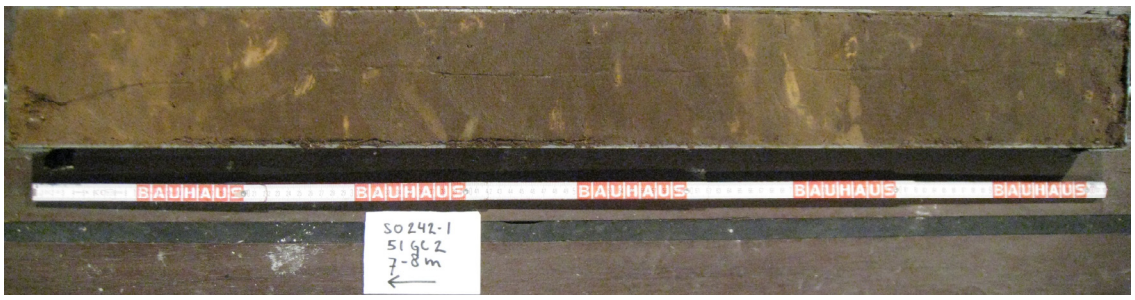
478-579



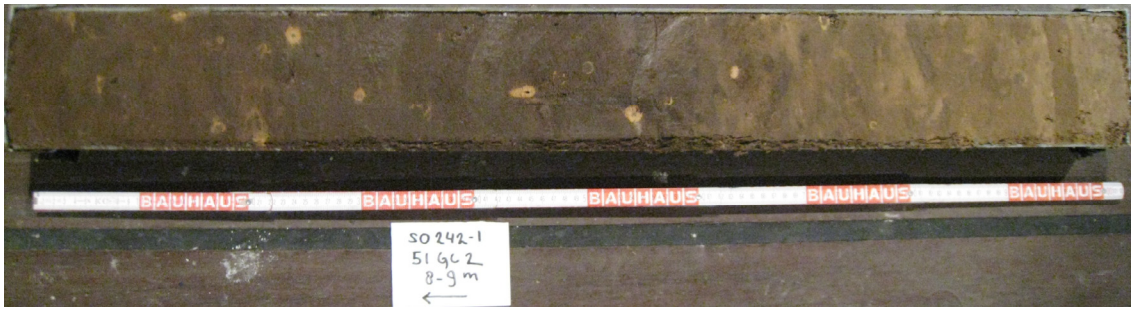
579-679



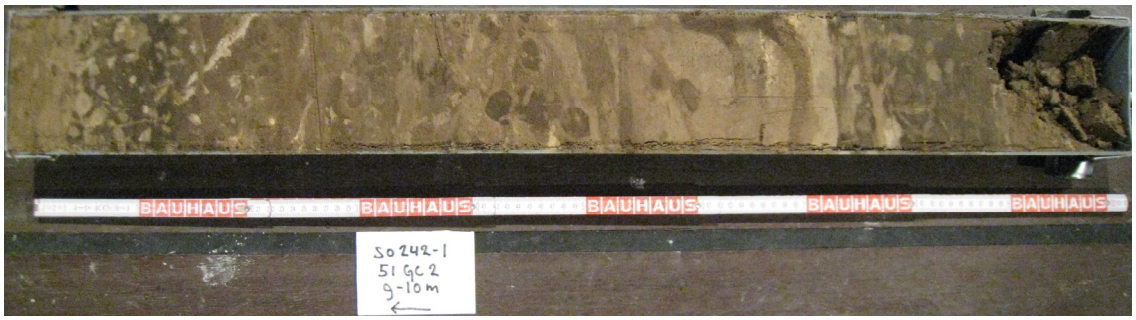
679-779



779-878



878-978



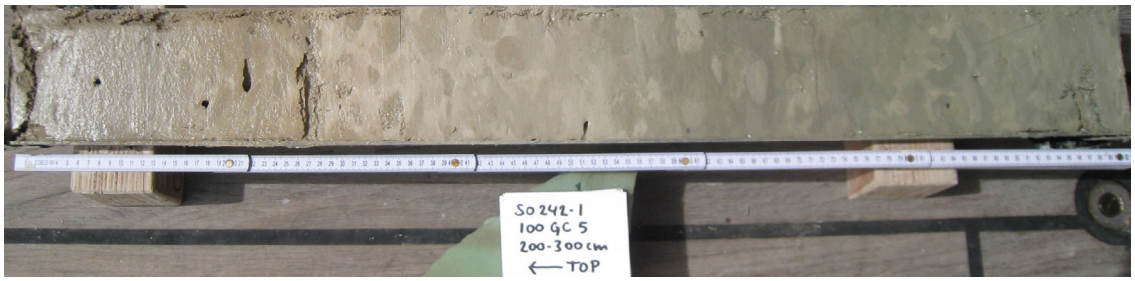
9.4.5 DEA trough

#100 GC 5 (0 – 878 cm)

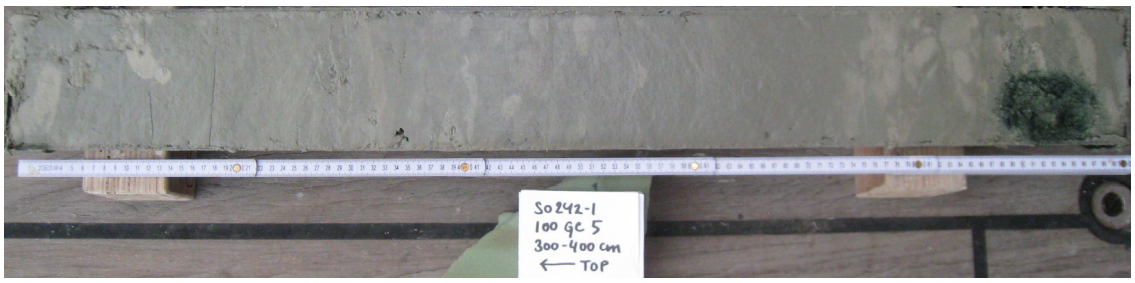
0-82

82-182

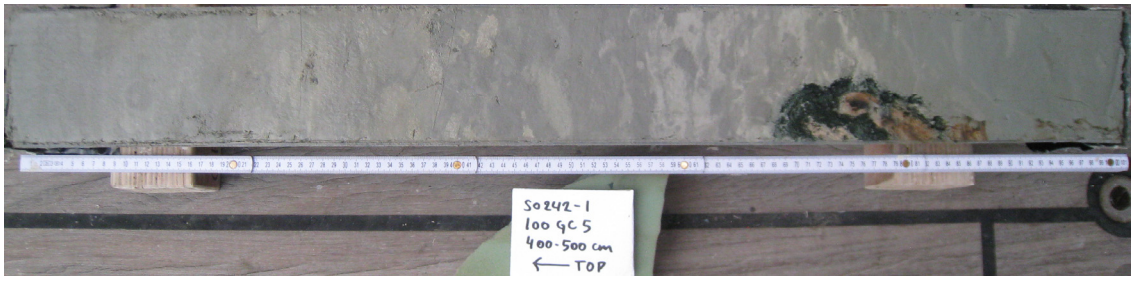
182-282



282-382

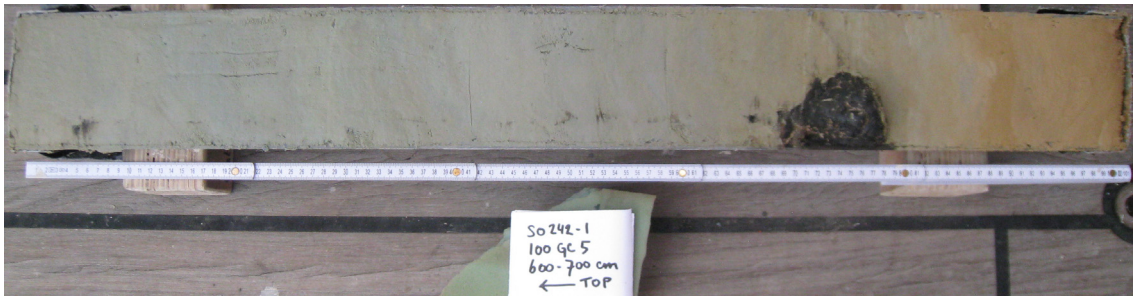


382-481



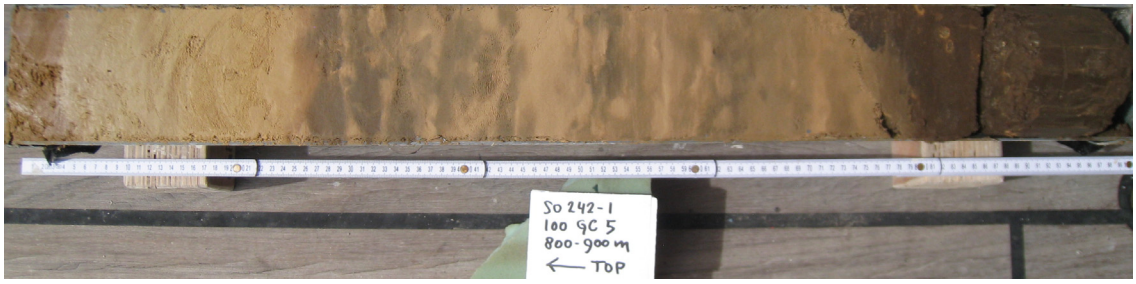
481-582

582-682



682-782

782-878



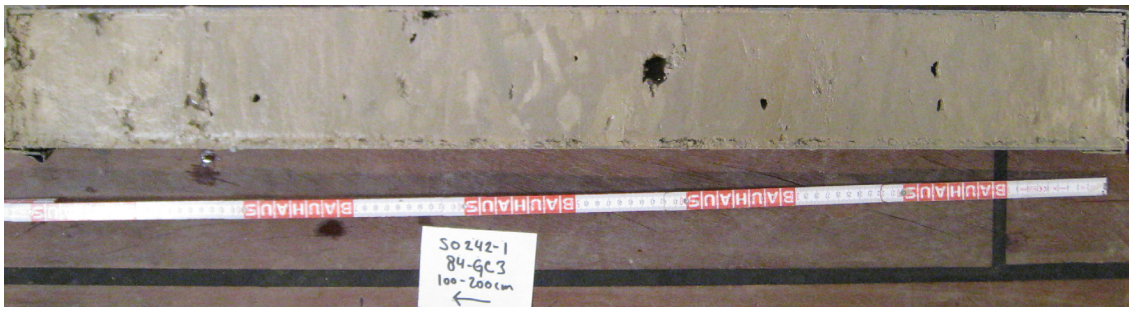
9.4.6 DEA sidescan sonar low backscatter area

#74 TV-MUC 20 (0 – 36 cm)

#84 GC 3 (0 – 947 cm)

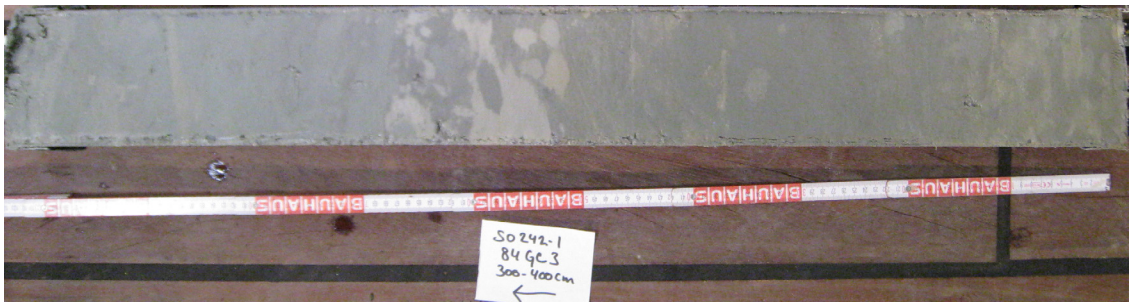
0-65

65-165

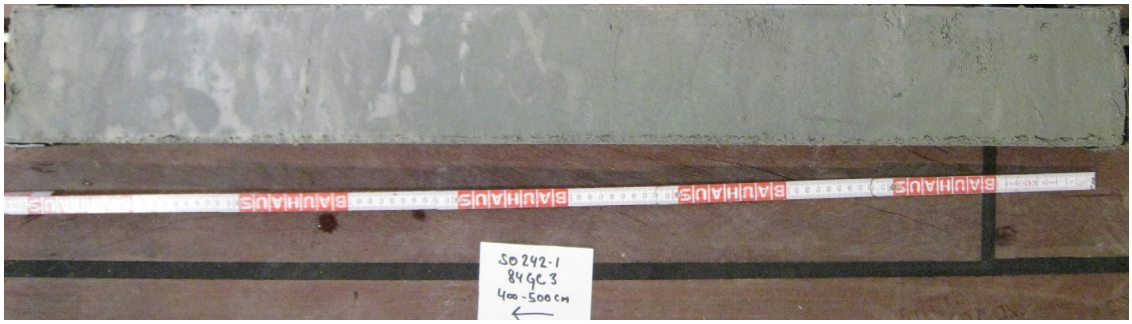


165-264

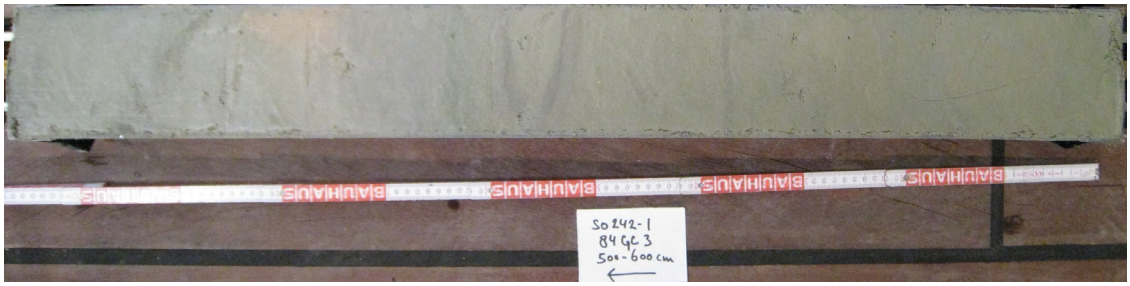
264-364



364-463



463-567



567-666

666-765

765-864

864-947

9.4.7 Crater small volcano

#129 BC 26 (0 – 35 cm)

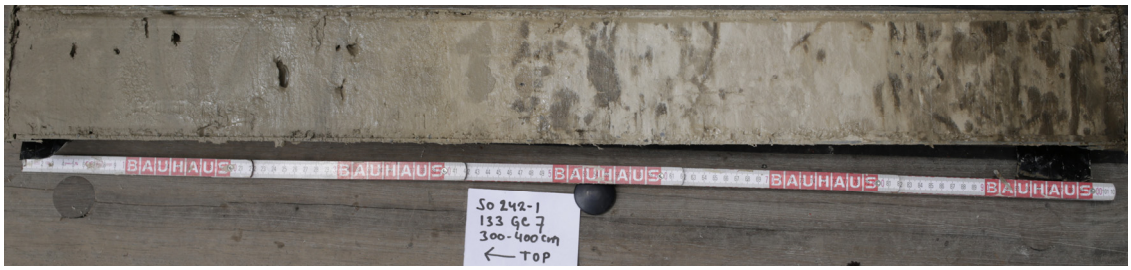
#132 GC 7 (0 – 936 cm)

0-50

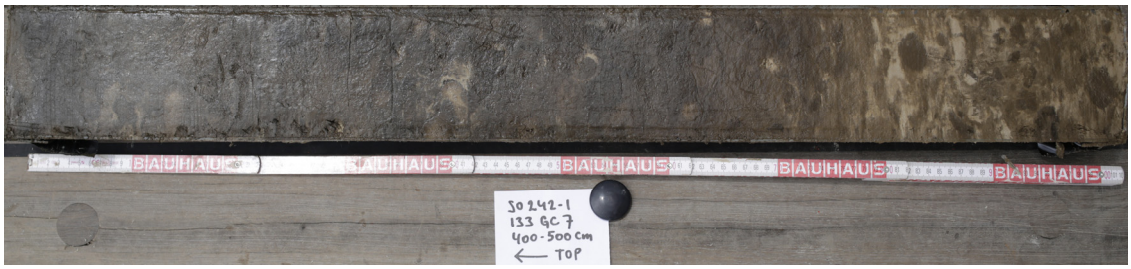
50-150

150-250

250-350



350-450



450-550

550-650

650-750

750-850

850-936

9.5 Gravity corer descriptions

Henko De Stigter

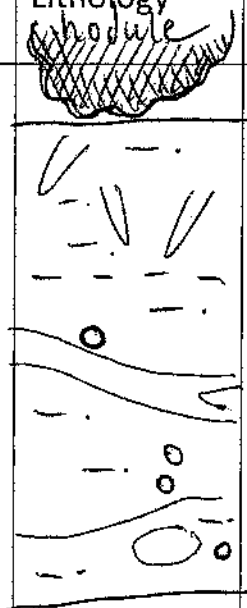
The following pages show the GC descriptions. No page numbers are given.

SO242/1 gravity core description

0-31 cm

Core: SO242-1 38 GC 1	Section: 0-100 cm
Date: 03-08-2015	Described by: HdS

General remarks: ~10 cm of soft watery brown mud from core top slumped out during core handling on deck. Large 10 cm ø nodule on top of core?



0-10cm: Mottled olive and dark grayish brown silty clay

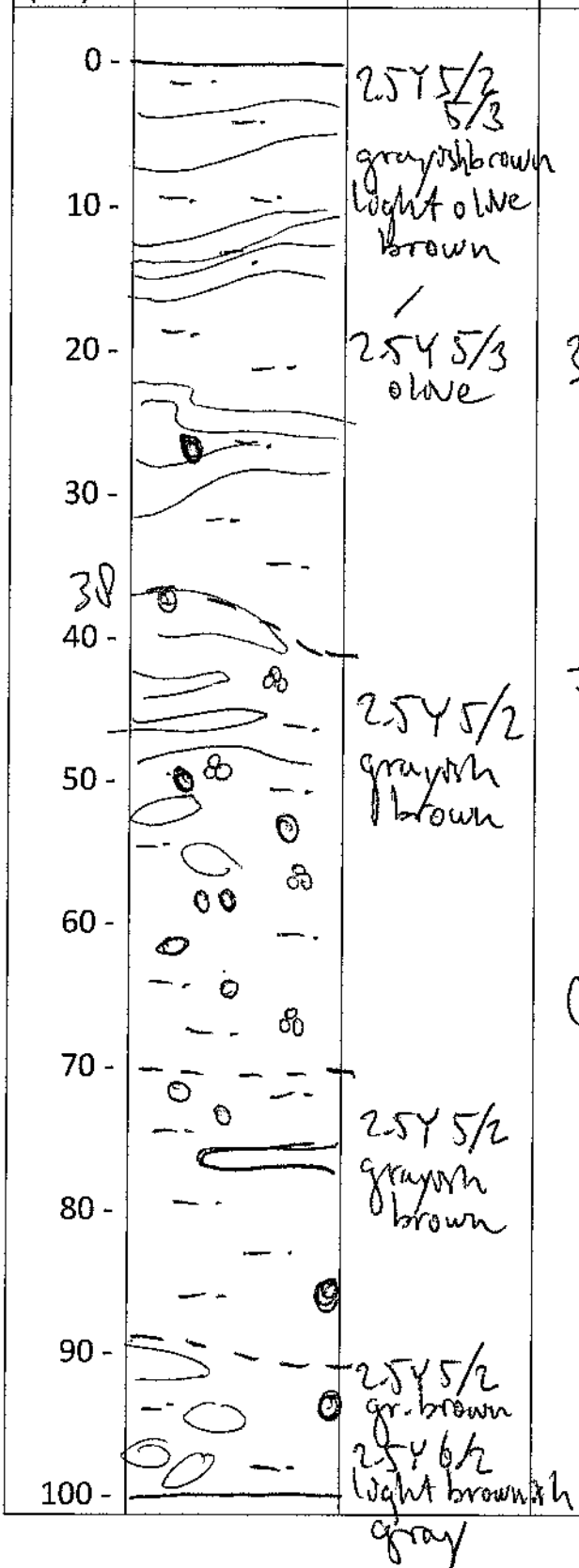
10-33cm: Vaguely mottled olive to grayish brown silty clay. Open or partially filled burrows 0.5-1 cm ø at 15, 23, 24, 29 cm Some with 2-mm long fecal pellets

SO242/1 gravity core description

31-131 cm

Core: SO242-1 38 GC 1	Section: 100-200 cm
Date: 03-08-2015	Described by: HJS

General remarks:



0-38 cm = Vaguely mottled grayish brown to light olive brown to olive silty clay with some darker subhorizontal bands. Open burrow 0.5 cm ø at 28 cm

38-70 cm: Slightly darker coloured mottled grayish brown silty clay with foraminifera. Open or partially filled burrows ~0.5 cm ø at 38, 50, 53, 59, 61, 64, 65 cm

70-90 cm: As above but with less visible foraminifera. Burrows filled with watery mud and with fecal pellets at 71, 73, 85 cm. Large open burrow 1 cm ø at 76 cm

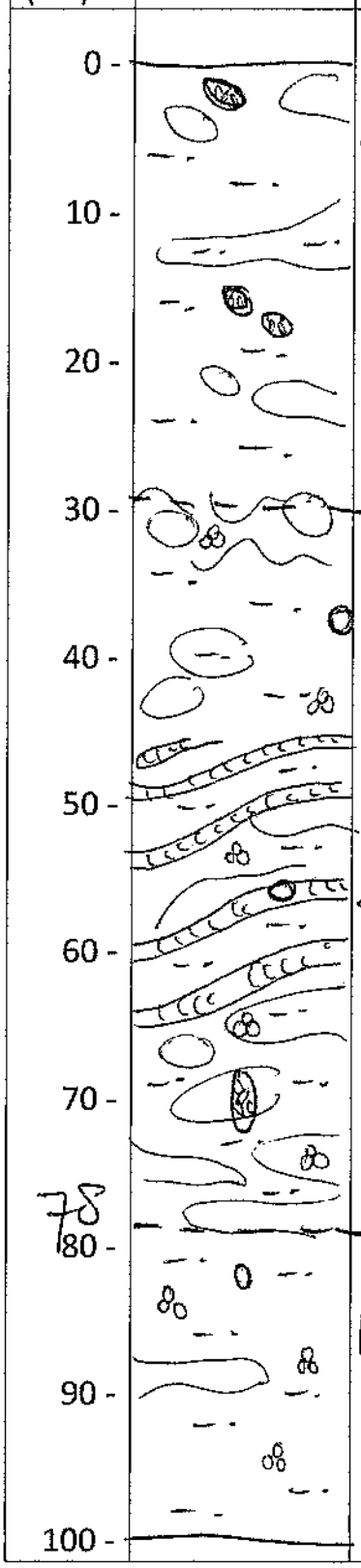
90-100 cm: Mottled grayish brown to light brownish gray silty clay. Large open burrow 1.5 cm ø at 94 cm.

SO242/1 gravity core description

131-231 cm

Core: SO242-1 38 GC1	Section: 200-300 cm
Date: 03-08-2015	Described by: HJS

General remarks:



0-30 cm: Mottled grayish brown to light brownish gray silty clay. Large open burrow 1 cm ⌀ with fecal pellets at 2 cm, and burrows 0.5-1 cm ⌀ with watery mud and pellets at 16-18 cm. Gradual transition to:

30-78 cm: Distinctly mottled light gray and grayish brown silty clay with foraminifera. Backfilled subhorizontal to oblique burrow traces 0.5-1 cm ⌀ at 47-49, 49-53, 56-60, 61-64 cm. Large open burrow 1 cm ⌀ at 39 cm, burrow with watery mud and fecal pellets at 70 cm. Gradual transition to:

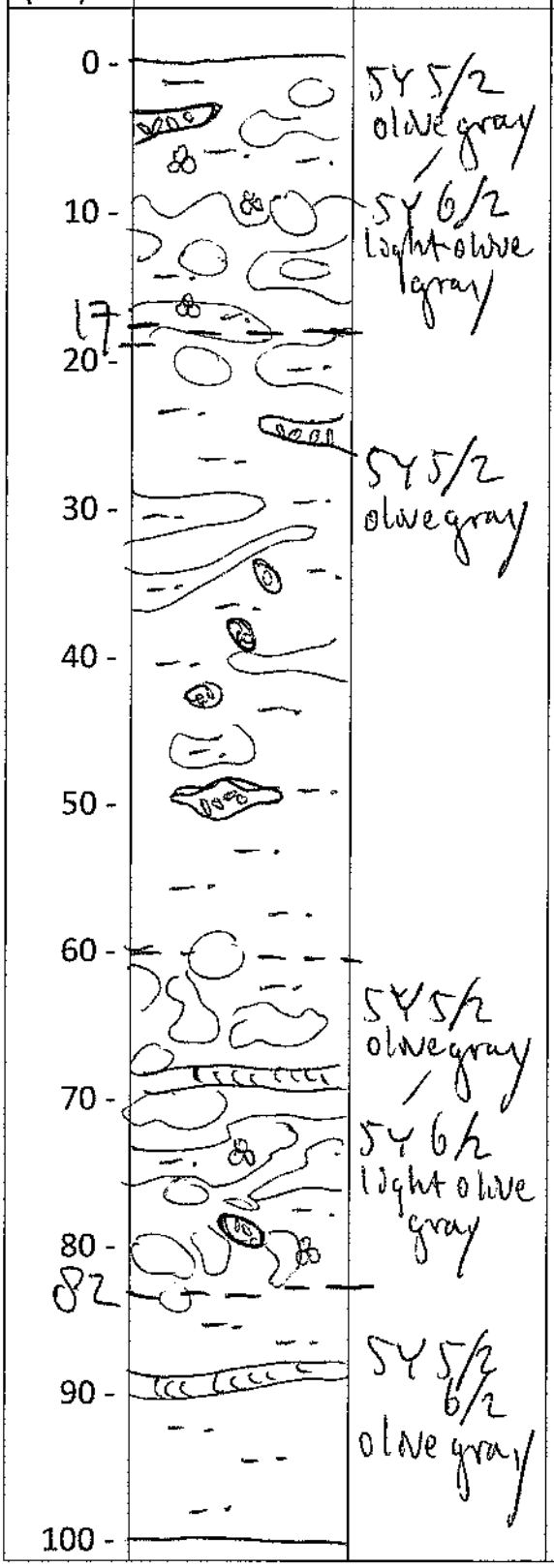
78-100 cm: Mottled light brownish gray silty clay with foraminifera. Open burrow 0.5 cm ⌀ at 82 cm.

SO242/1 gravity core description

231 - 332 cm

Core: SO242-1 38 GC1	Section: 300-400 cm
Date: 03-08-2015	Described by: HDS

General remarks:



0-17 cm: Distinctly mottled olive gray to light olive gray silty clay with some foraminifera. Open burrow with fecal pellets at 4 cm.

17-60 cm: Homogeneous olive gray silty clay with a few patches in lighter shades of olive gray. Burrows 1 cm ø with watery mud and fecal pellets, some half open, at 24, 33, 37, 42, 50 cm.

60-82 cm: Distinctly mottled olive gray and light olive gray silty clay. Burrow 1 cm ø filled with watery mud and pellets at 78 cm. Back filled horizontal burrow trace 1 cm ø at 69 cm.

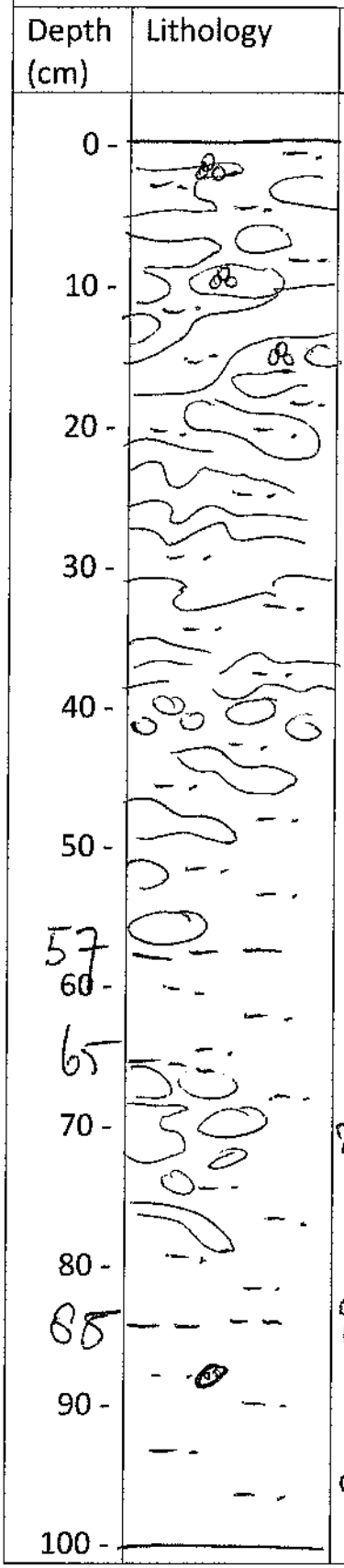
82-100 cm: Homogeneous to vaguely mottled olive gray silty clay. Back filled horizontal burrow 0.5-1 cm ø at 89 cm.

SO242/1 gravity core description

331-431 cm

Core: SO242-1 38 GC 1	Section: 400-500 cm
Date: 03-08-2015	Described by: HDS

General remarks:



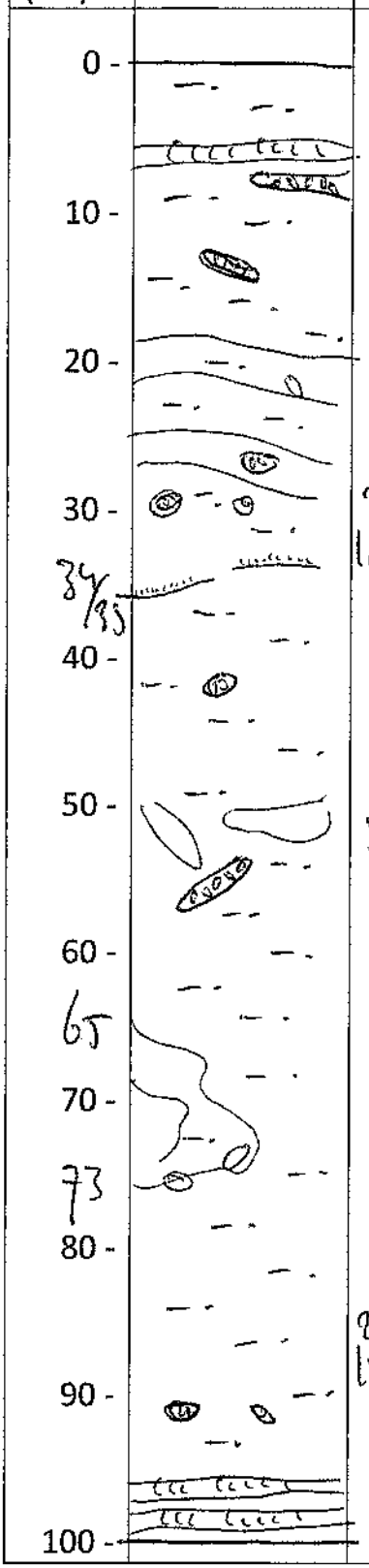
Depth (cm)	Colour	Description
0 - 57	5Y5/2 olive gray 5Y6/2 light olive gray	0-57 cm: Mottled to distinctly mottled olive gray to light olive gray and light gray silty clay with some foraminifera in upper part. From 37-57 cm distinct light gray patches against darker background.
57 - 100	5Y5/2 olive gray 5Y7/2 light gray 2.5Y5/2 6/2 light brownish gray to grayish brown 5Y5/2 olive gray	57-100 cm: Homogeneous to vaguely mottled olive gray silty clay. Diffuse brownish haze from 65-85 cm, not only at surface of split core, thus representing original colour.

SO242/1 gravity core description

431-531 cm

Core: SO242-1 38 GC1	Section: 500-600 cm
Date: 03-08-2015	Described by: HJS

General remarks:



Description

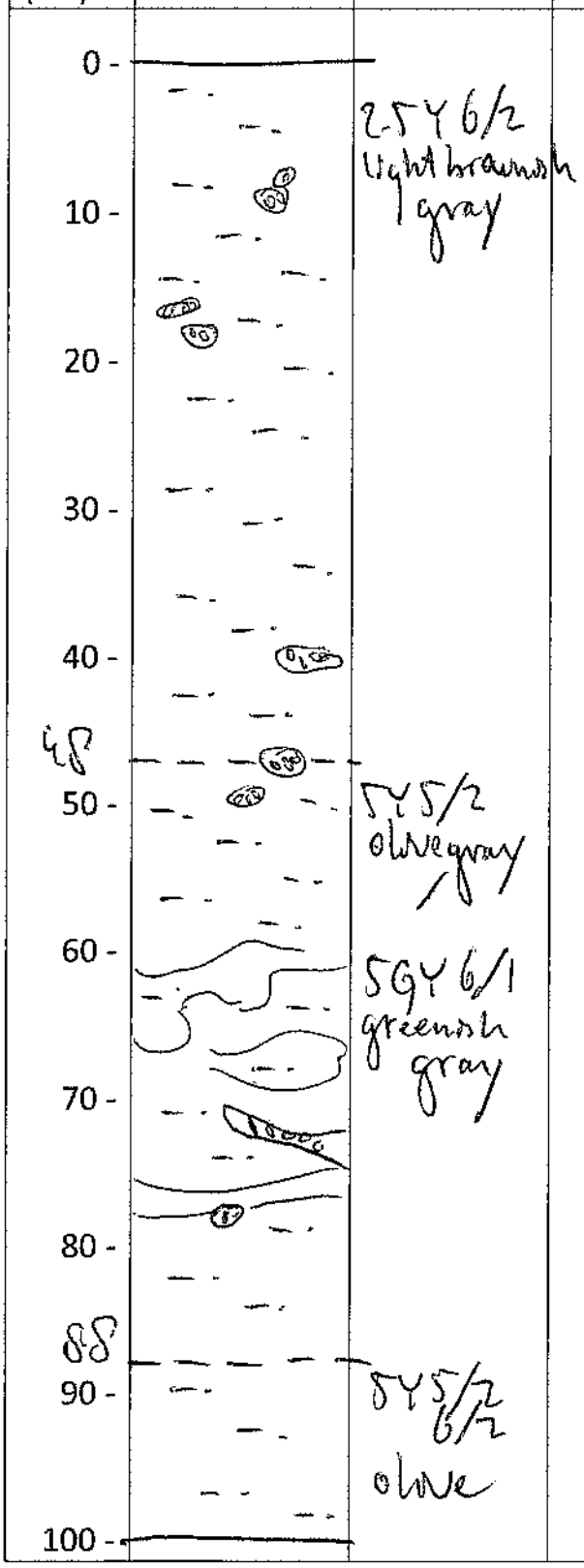
0-100 cm: Homogeneous to vaguely mottled and cloudy light olive gray to light brownish gray silty clay.
Burrows 0.5-1 cm Ø filled with watery mud and fecal pellets at 8, 14, 27, 55-59, 93 cm, open burrows at 22, 30, 42, 77 cm.
Discontinuous thin undulated dark rusty brown layer at 34, 35 cm.
Brownish haze in lower part of section, notably 65-73 cm.
Back filled horizontal burrow traces 0.5-1 cm Ø at 6, 97, 98 cm.

SO242/1 gravity core description

531-632 cm

Core: SO242-1 38 GC 1	Section: 600-700 cm
Date: 03-08-2015	Described by: HJS

General remarks:



0-48 cm: Vaguely mottled to cloudy light brownish gray silty clay. Burrows 0.5-1 cm Ø filled with watery mud and fecal pellets at 9, 10, 15, 17, 40 cm. Gradual transition to:

48-88 cm: Mottled to cloudy olive gray to distinctly greenish gray silty clay. Burrows 0.5-1 cm Ø filled with soft mud and pellets at 48, 50, 71-72, 76 cm. Gradual transition to:

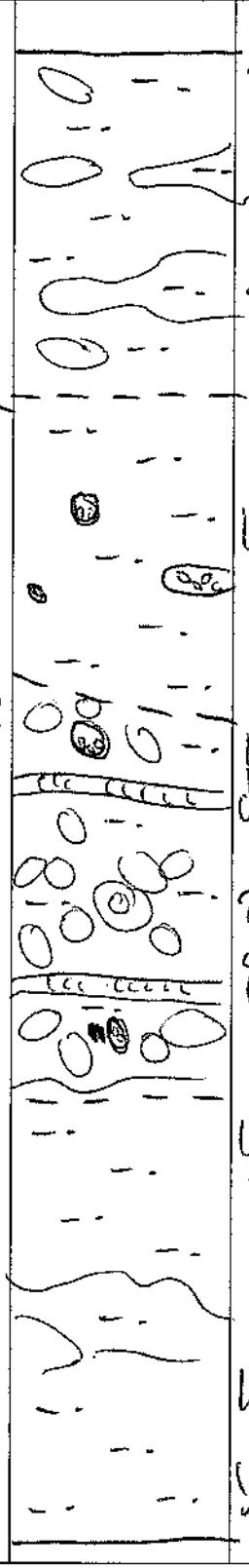
88-100 cm: Olive gray silty clay

SO242/1 gravity core description

631-731 cm

Core: SO242-1 38 GC 1	Section: 700-800 cm
Date: 03-08-2015	Described by: HJS

General remarks:



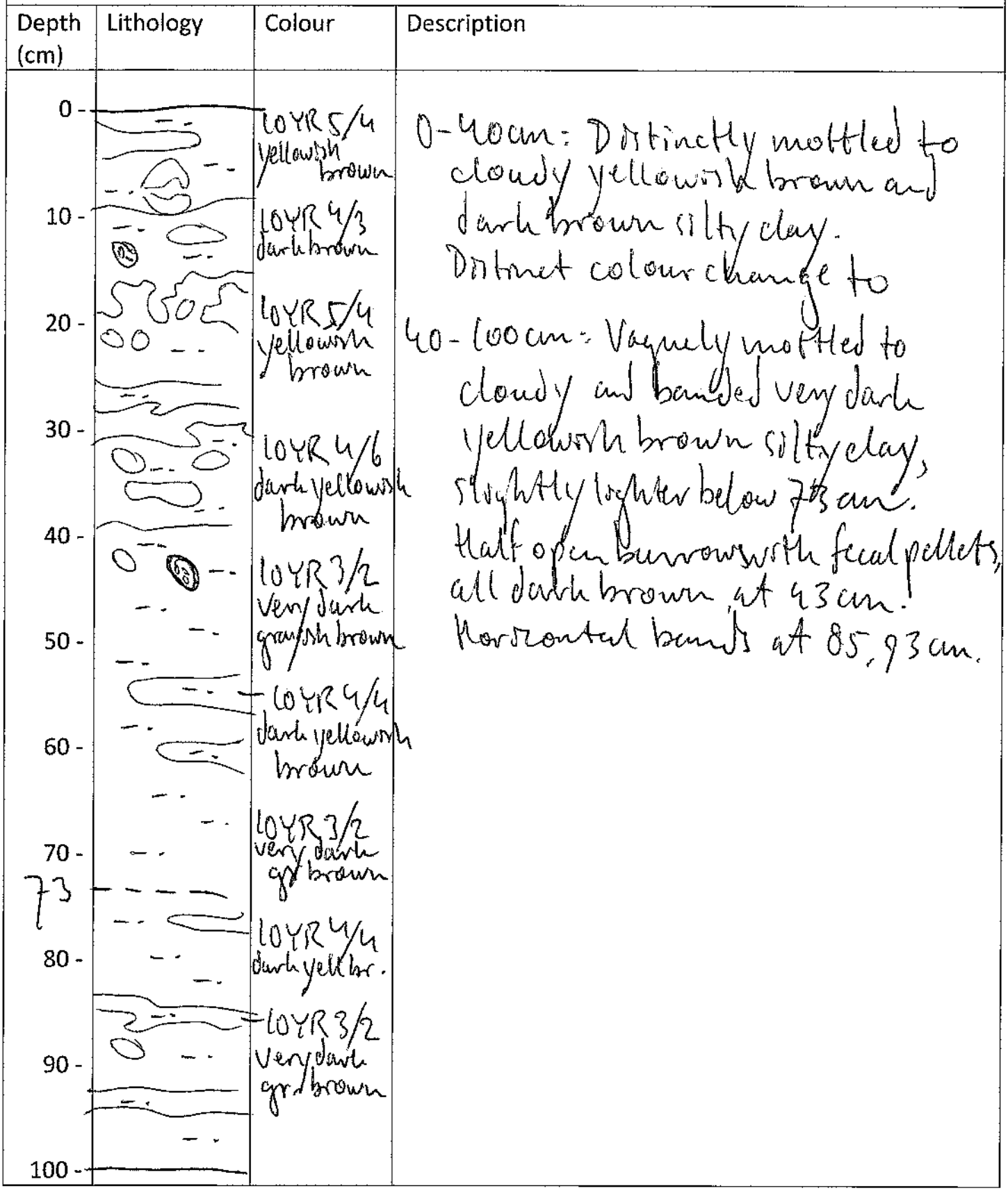
Depth (cm)	Lithology	Colour	Description
0 - 100		2.5Y 6/3 pale olive; 2.5Y 5/4 olive; 2.5Y 6/2 light olive gray; 2.5Y 6/3 light yellowish brown; 10YR 4/4 dark yellowish brown; 2.5Y 5/2 grayish brown; 10YR 5/4 yellowish brown; 10YR 6/4 light yellowish brown	0-22 cm: Mottled to cloudy pale olive and light olive gray silty clay. Gradual transition to: 22-41/43 cm: Homogeneous light yellowish brown silty clay. Burrow 1 cm Ø with soft mud and fecal pellets at 35 cm. Open burrows 0.5 cm Ø at 30 and 35 cm. Distinct colour change to: 41/43-70 cm: Distinctly mottled dark yellowish brown to grayish brown silty clay with lighter brown patches. Back filled horizontal burrow 0.5 cm Ø at 48, 63 cm. Open burrows at 46, 48, 66 cm. Black Mn-oxide? concretion ~ 0.5 cm Ø at 65 cm. Gradual transition to: 70-100 cm: Mottled to cloudy light olive brown to yellowish brown silty clay.

SO242/1 gravity core description

731-831 cm

Core: SO242-1 38 GC1	Section: 800-900 cm
Date: 03-08-2015	Described by: HdS

General remarks:



SO242/1 gravity core description

831-917 cm

Core: SO242-1 38 GC1	Section: 900-1000 cm
Date: 03-08-2015	Described by: HDS

General remarks:

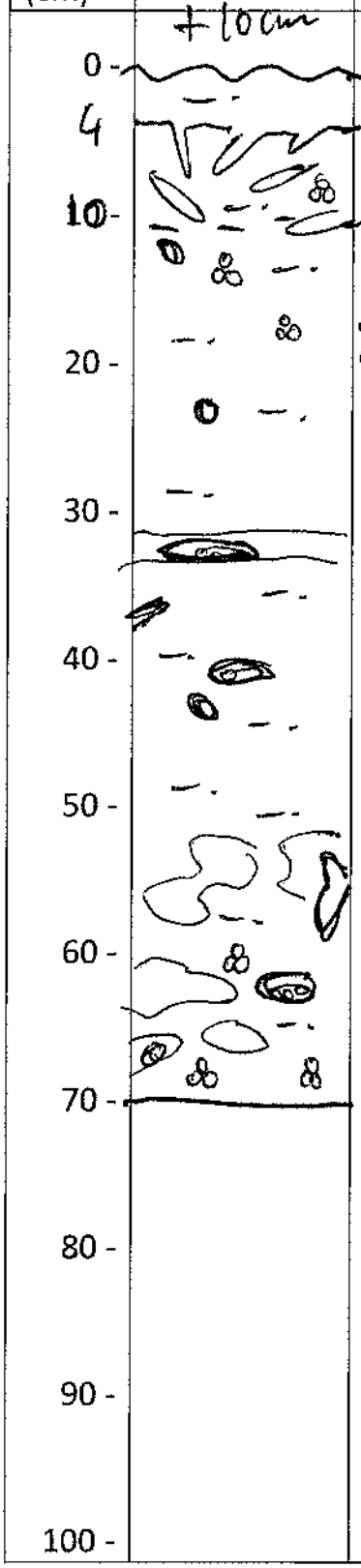
Depth (cm)	Lithology	Colour	Description
0 -		10YR 4/3 dark brown	0-86 cm: Vaguely mottled to cloudy yellowish brown to dark brown silty clay
10 -		10YR 5/4 yellowish brown	
20 -			
30 -		10YR 4/4 dark yellowish brown	
40 -			
50 -			
60 -		10YR 4/2 dark grayish brown	
70 -			
80 -		10YR 4/3 dark brown	
86			
90 -	core catcher		
100 -			

SO242/1 gravity core description

0-80cm

Core: SO242/1-51 GC2	Section: 0-100 cm
Date: 05-08-2015	Described by: HIS

General remarks: top ~ 10 cm very soft watery brown mud flown out during core recovery, mostly on sampling half of core



0-4cm: soft, dark brown silty clay.

4-10cm: mottled dark brown and grayish brown silty clay

10-70cm: mottled / cloudy grayish brown and light olive brown silty clay, foraminifera common from 10-30 and 60-70cm

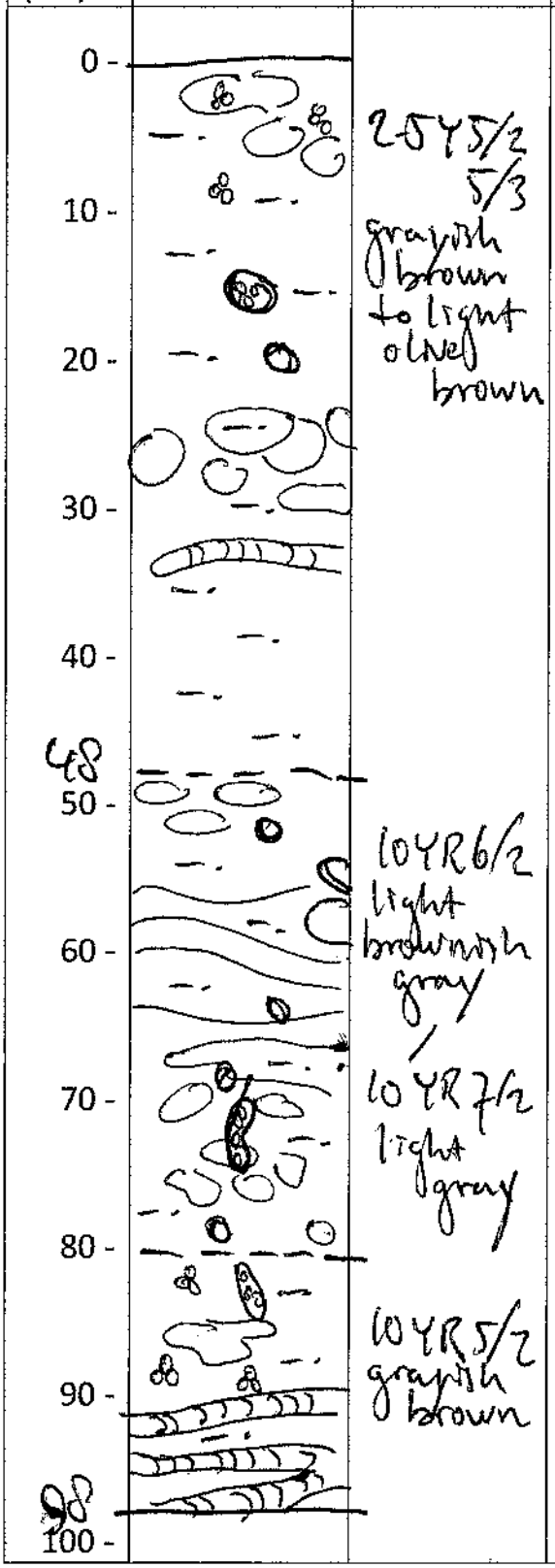
Burrows 0.5-1 cm ø partially open or filled with soft watery mud at 13, 23, 32, 37, 42, 43 55-58, 61, 67cm.

SO242/1 gravity core description

80-178 cm

Core: SO242/1-51GC2	Section: 100-200 cm
Date: 05-08-2015	Described by: HdS

General remarks:



Description

0-48 cm = mottled grayish brown to light olive brown silty clay with occasional foraminifera from 0-10 cm. Burrows 0.5-1 cm Ø, open or partially filled with watery mud at 16, 26 cm. Backfilled horizontal burrow ~1 cm Ø at 32 cm

48-80 cm = distinctly mottled light brownish gray and light gray silty clay. Open or half filled burrows 0.5-1 cm at 51, 55, 62 68, 72-75, 78 cm.

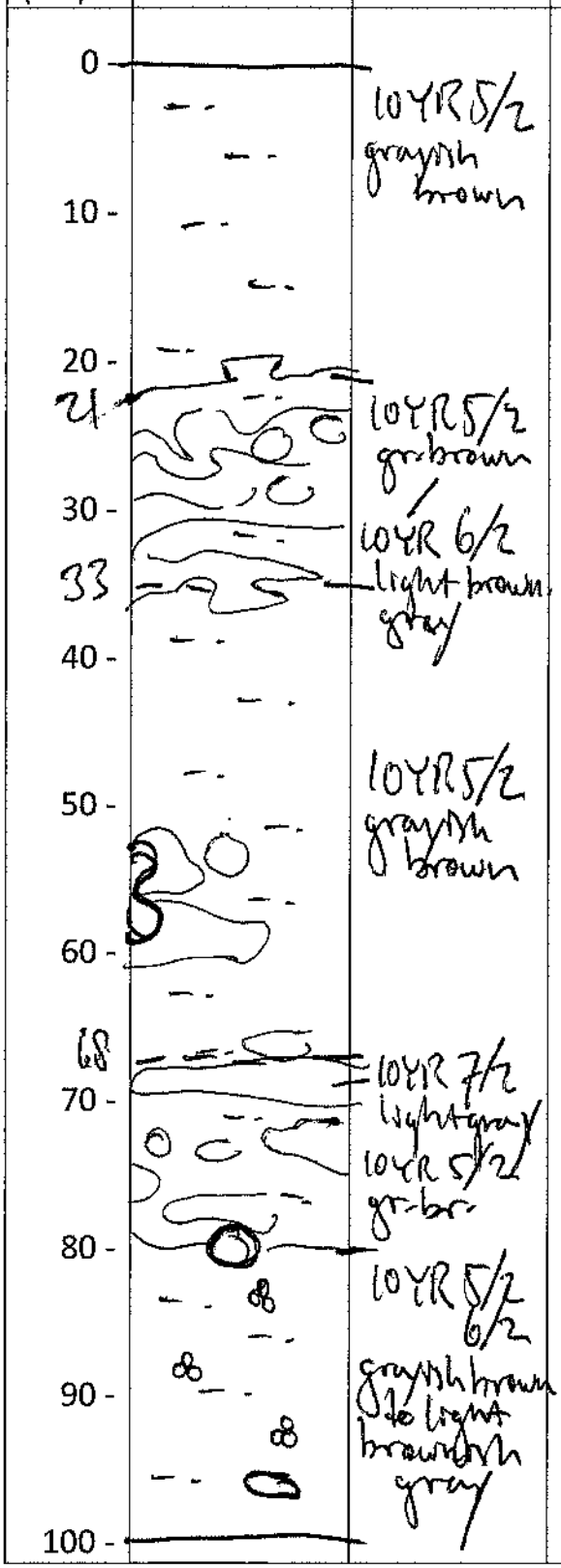
80-98 cm = mottled grayish brown silty clay with occasional forams. Backfilled horizontal burrows (empty) at 91, 95, 97 cm

SO242/1 gravity core description

178-278 cm

Core: SO 242/1 - 51GC2	Section: 200 - 300 cm
Date: 05-08-2015	Described by: HDS

General remarks:



0 - 21 cm: homogeneous to vaguely mottled grayish brown silty clay

21 - 33 cm: distinctly mottled grayish brown and light brownish gray silty clay

33 - 68 cm: homogeneous to vaguely mottled grayish brown silty clay - Open burrow 1 cm ⌀ at 53.55 cm

68 - 80 cm: distinctly mottled light gray and grayish brown silty clay. Large open burrow 1-2 cm ⌀ at 78-down

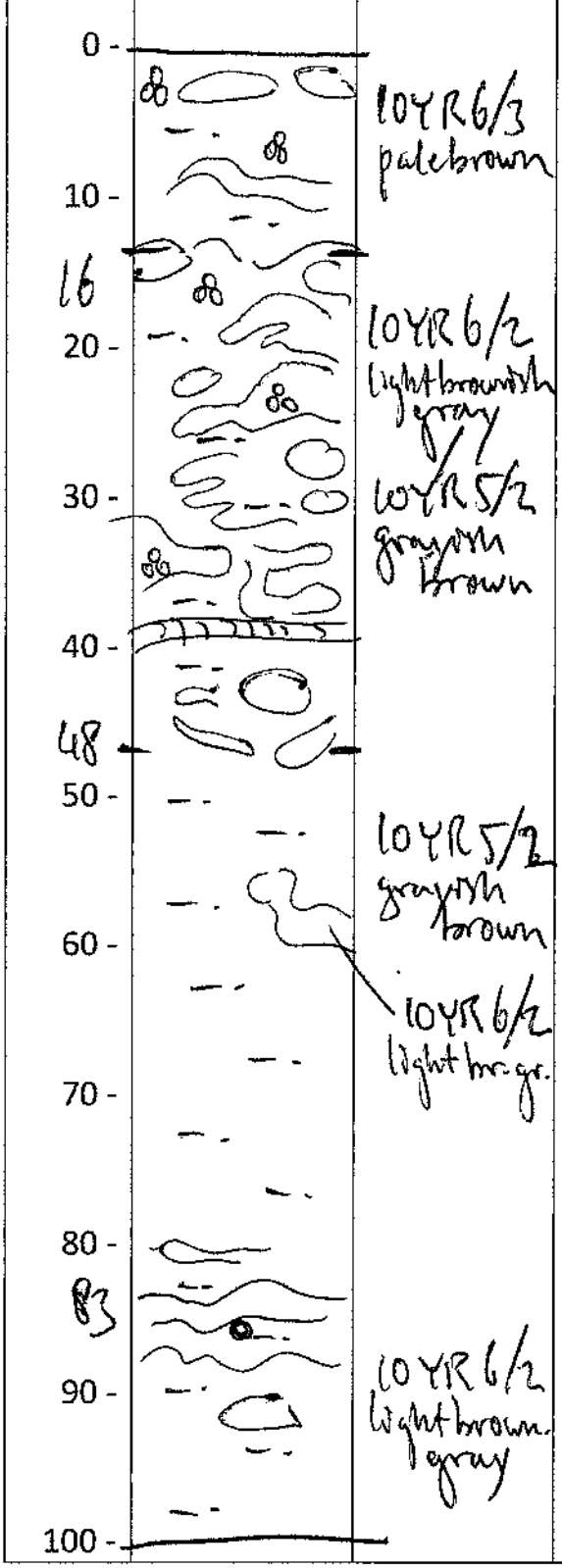
80 - 100 cm: Vaguely mottled to cloudy grayish brown silty clay with foraminifera.
Open to half filled burrow 0.5 cm ⌀ at 97 cm.

SO242/1 gravity core description

278-378 cm

Core: SO242/1-57 GC2	Section: 300-400 cm
Date: 05-08-2015	Described by: HJS

General remarks:



Description

0-16 cm = vaguely mottled to cloudy pale brown silty clay with foraminifera

16-48 cm: distinctly mottled to cloudy light brownish gray to grayish brown silty clay with foraminifera. Backfilled horizontal burrow (empty) at 39 cm. Isolated light patches from 40-48 cm.

48-83 cm = homogeneous grayish brown silty clay. Isolated lighter patch at 57-60 cm

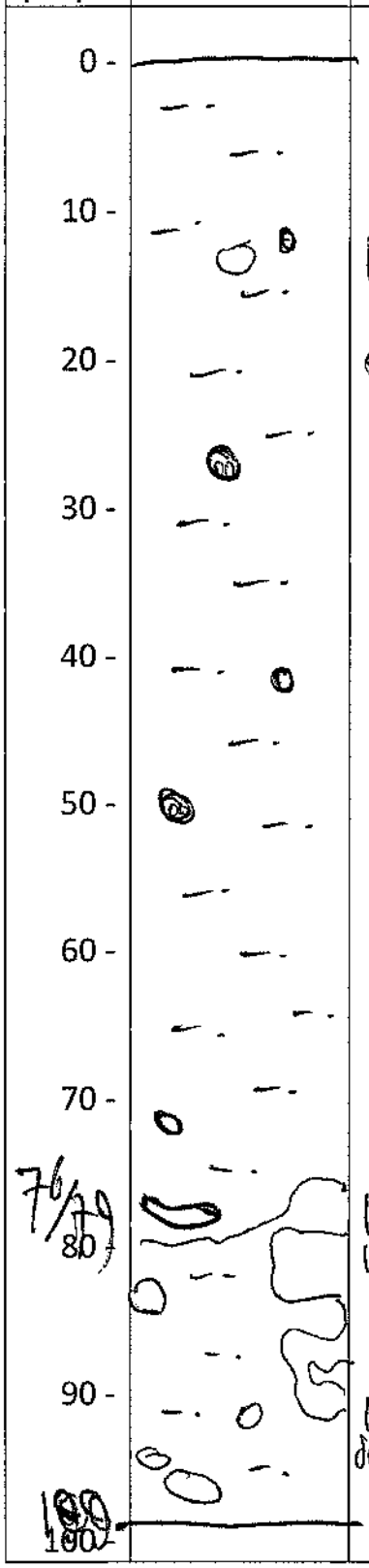
83-100 cm: Mottled to cloudy light brownish gray silty clay. Open burrow at 87 cm.

SO242/1 gravity core description

378 - 478 cm

Core: SO242/1-51GC2	Section: 400 - 500 cm
Date: 05-08-2015	Described by: HJS

General remarks:



0 - 76/79 cm: homogeneous to faintly mottled light brownish gray to pale brown silty clay. Open to partially filled burrows 0.5-1 cm ø at 12, 29, 42, 50, 71, 78 cm. Distinct irregular colour change to:

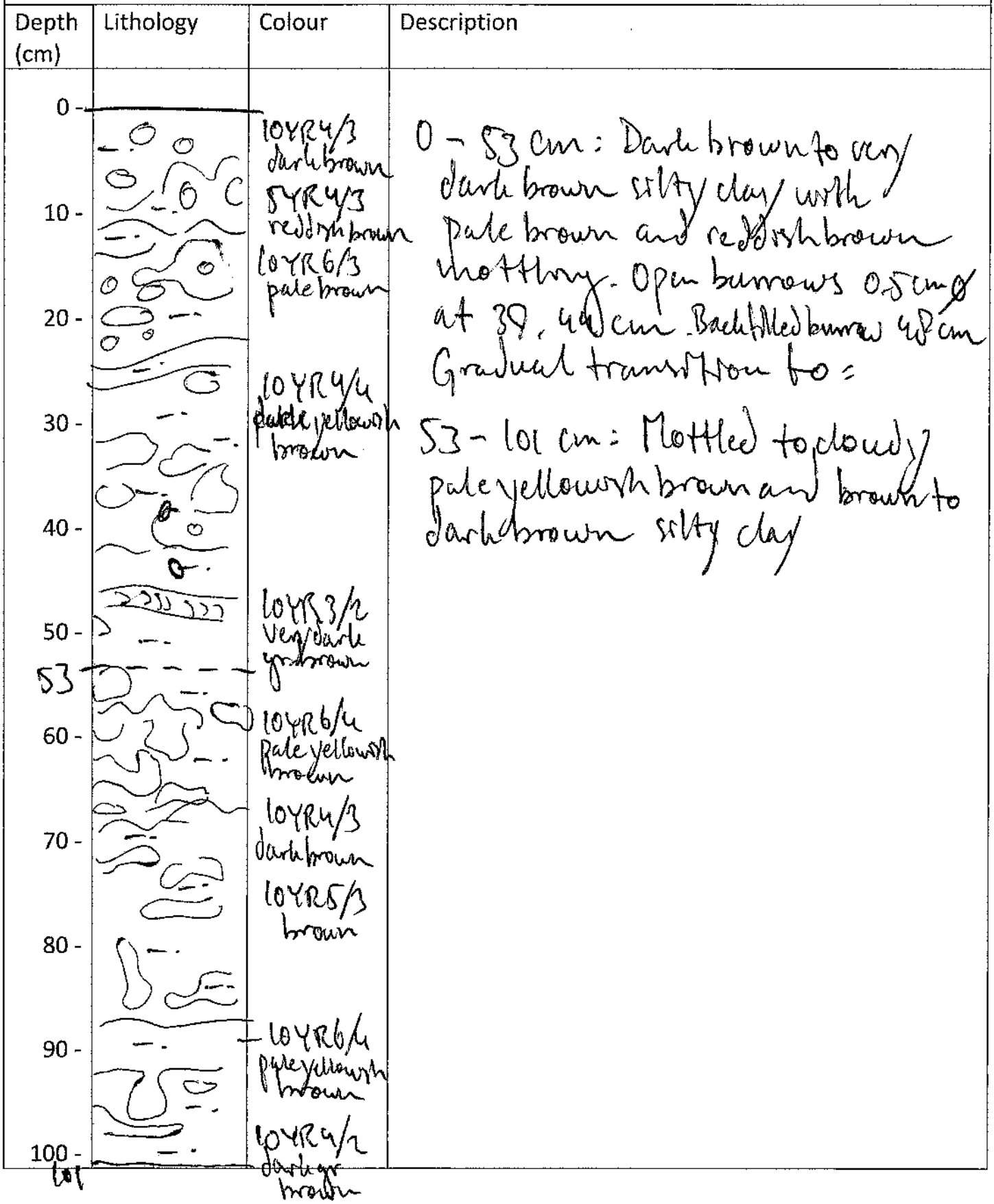
76/79 - 100 cm: distinctly mottled light and dark yellowish brown silty clay, more consolidated than overlying gray interval

SO242/1 gravity core description

478-579 cm

Core: SO242/1-51 GC2	Section: 500-600 cm
Date: 05-08-2015	Described by: HJS

General remarks:

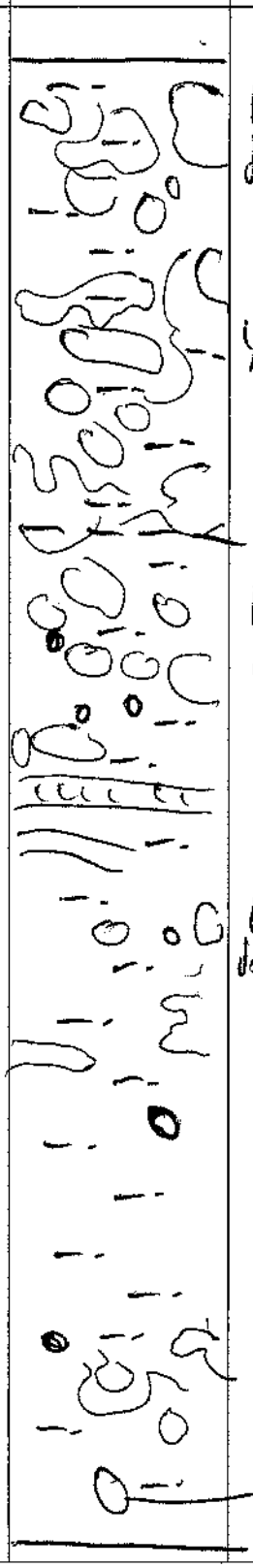


SO242/1 gravity core description

579-679 cm

Core: SO242/1-51 GC2	Section: 600-700 cm
Date: 05-08-2015	Described by: HJS

General remarks:

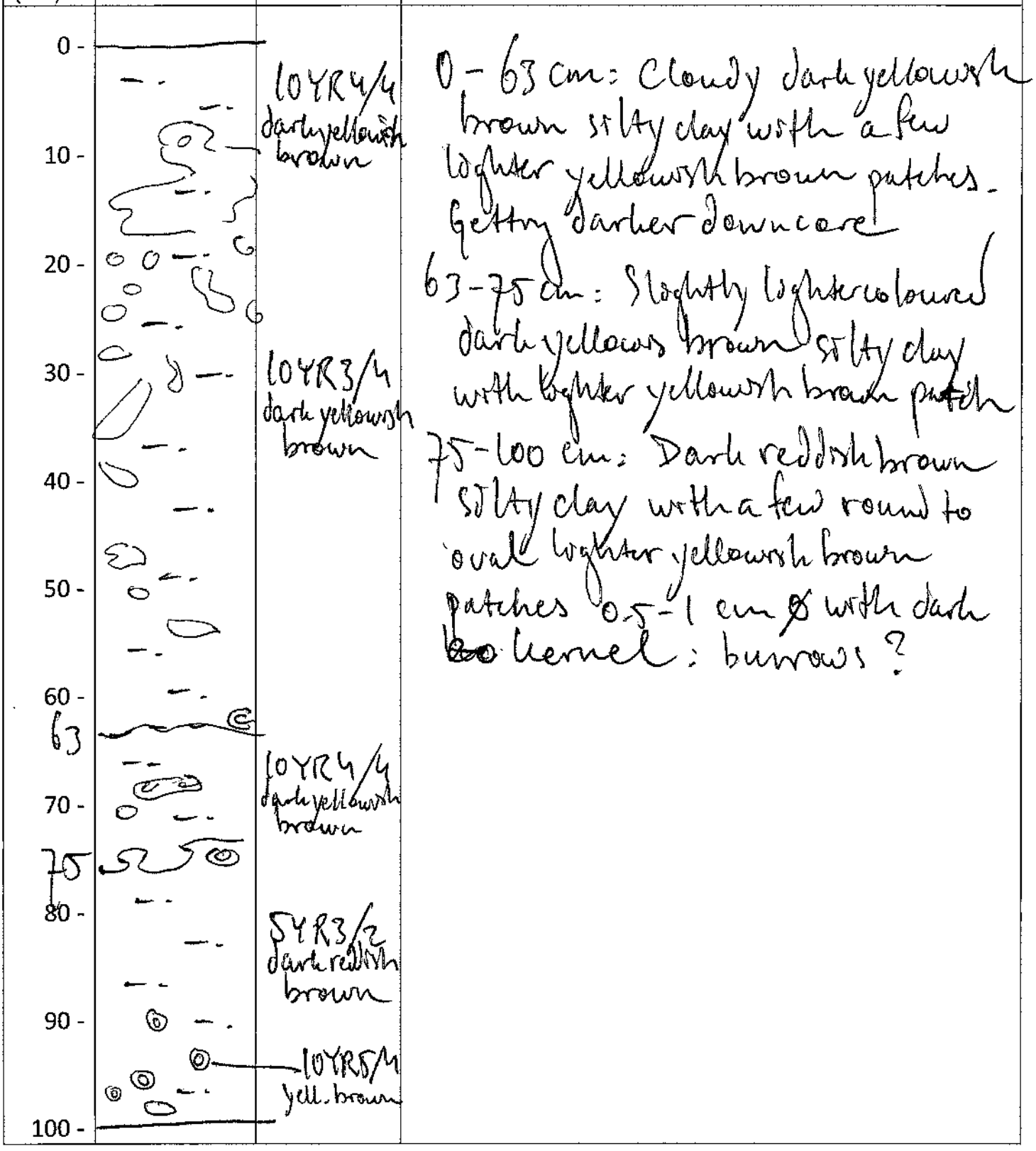
Depth (cm)	Lithology	Colour	Description
0 - 100		10YR4/3 dark brown; 10YR5/4 yellowish brown; 10YR4/3 dark brown; 10YR3/4 dark yellowish brown; 10YR5/4 yell. br.	0-30 cm: distinctly mottled to cloudy dark brown and yellowish brown silty clay. Gradual transition to: 30-100 cm: Vaguely mottled to cloudy dark brown to dark yellowish brown silty clay. Open burrows 2-5 mm ø at 39, 44, 59, 72, 87 cm. Vaguely outlined backfilled burrow at 49-50 cm. Occasional yellowish brown patches

SO242/1 gravity core description

679-779 cm

Core: SO242/1-51 GC2	Section: 700-800 cm
Date: 05-08-2015	Described by: HJS

General remarks:

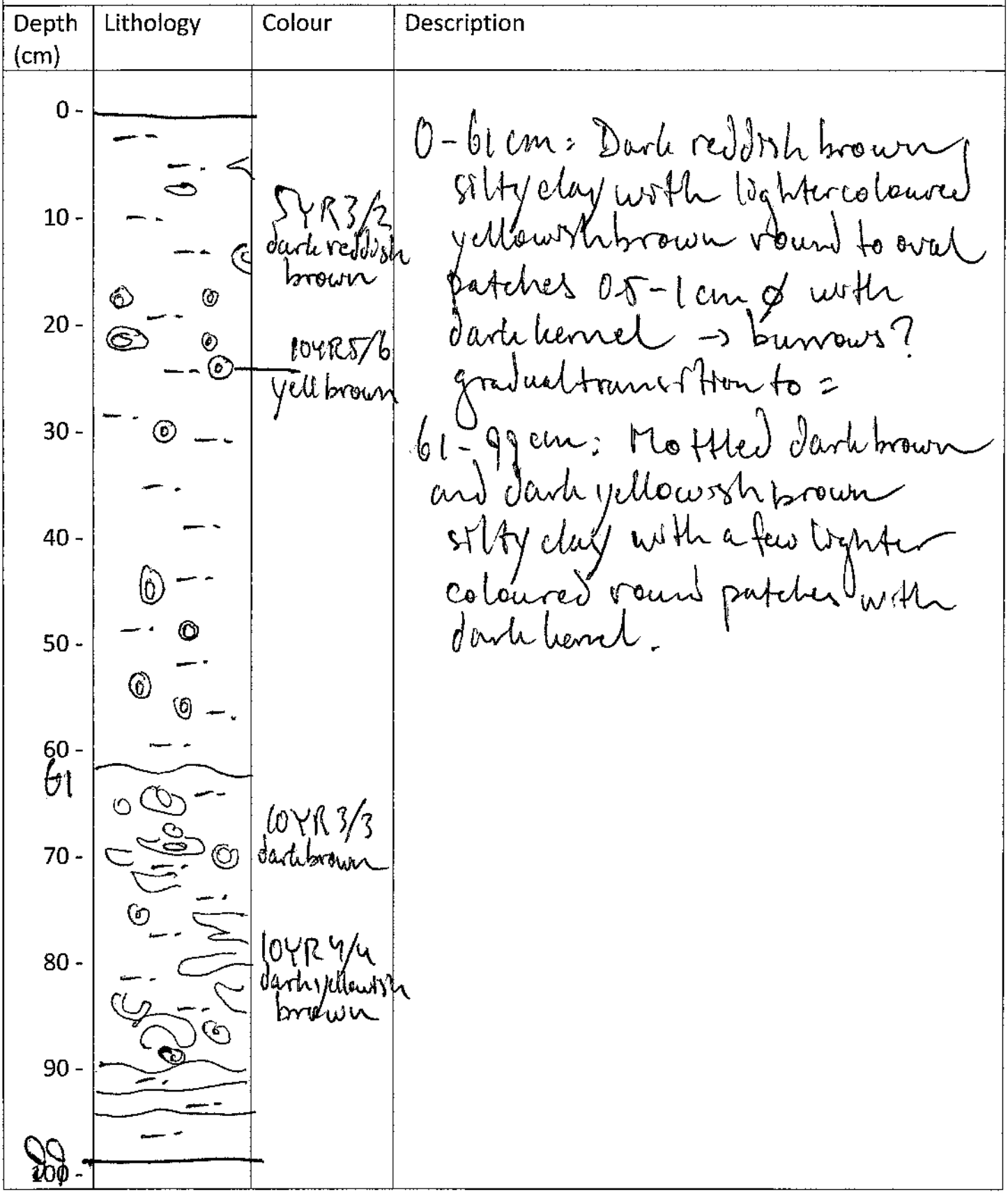


SO242/1 gravity core description

779-878 cm

Core: SO242/1-51 GC 2	Section: 800-900 cm
Date: 05-08-2015	Described by: HJS

General remarks:

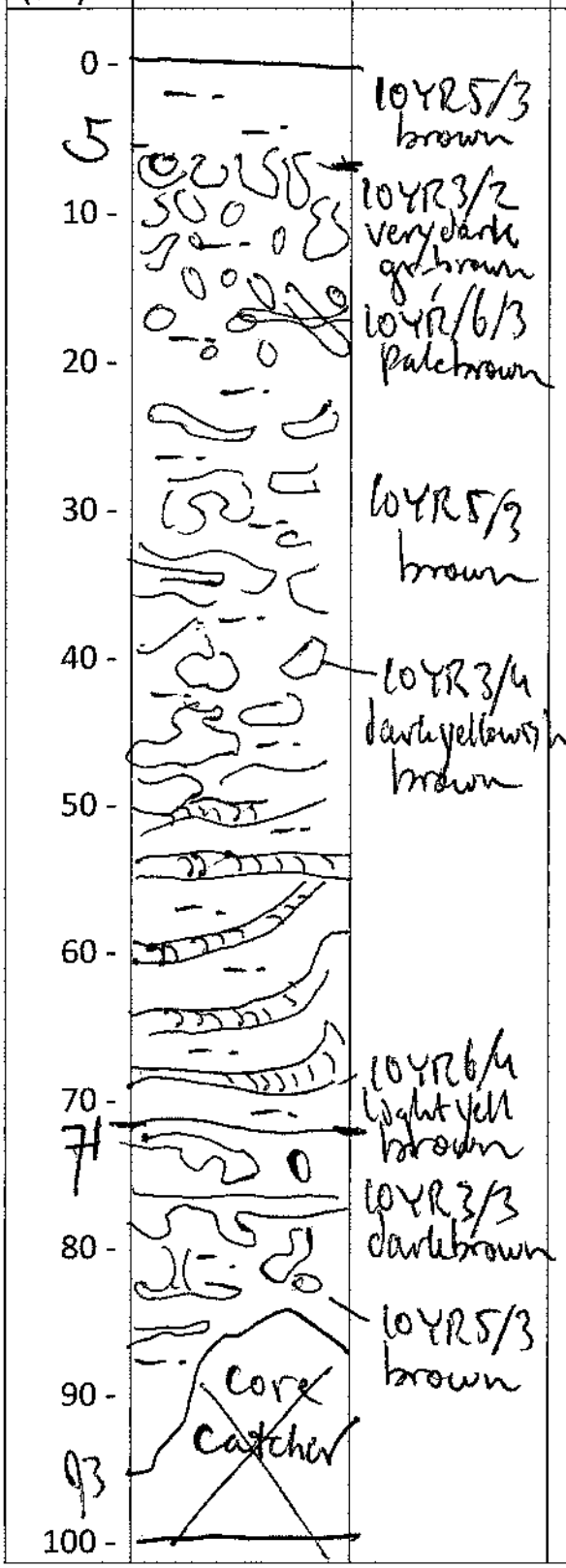


SO242/1 gravity core description

878-971 cm

Core: SO 242/1 - 51 GC 2	Section: 900 - 1000 cm
Date: 05-08-2015	Described by: HJS

General remarks:



0-5cm: mottled to cloudy ~~brown~~ silty clay

5-71cm: distinctly mottled very dark grayish brown and pale brown silty clay, gradually turning to brown and light yellowish brown silty clay with darker mottling. Backfilled horizontal to oblique burrows 1 cm Ø at 51, 53, 55-58, 61-63, 66-68 cm

71-93 cm: Mottled dark brown and brown silty clay

SO242/1 gravity core description 0-65 cm

Core: SO242-1 84 GC 3	Section: 0-100 cm
Date: 13-08-2015	Described by: HDS

General remarks: dark brown water/mud at top of core slumped out during core handling on deck, mostly present in sampling half of core

Depth (cm)	Lithology	Colour	Description
0-13		5YR3/2 dark reddish brown	0-13 cm = soft dark reddish brown silty clay
13-22		5YR3/2 2.5Y5/2	13-22 cm: mottled dark reddish brown and grayish brown silty clay
22-65		2.5Y5/2 grayish brown	22-65 cm: vaguely mottled to homogenous grayish brown silty clay with some foraminifera. Open or half filled burrows 0.5-1 cm ø at 29, 41, 42, 59, 60 cm

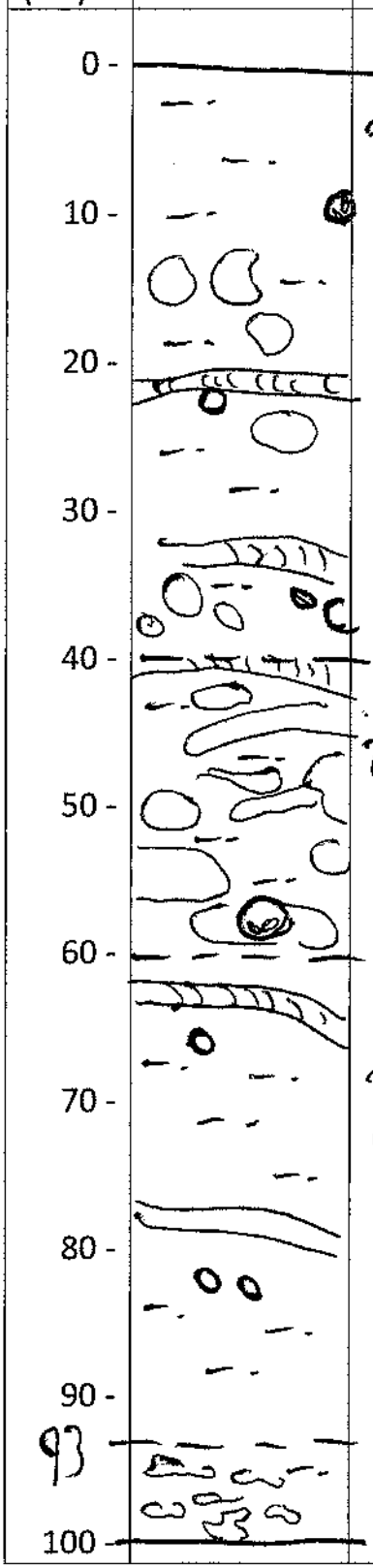
0 - 10 - 13 - 20 - 22 - 30 - 40 - 50 - 60 - 65 - 70 - 80 - 90 - 100 -

SO242/1 gravity core description

65-165 cm

Core: SO242-1 84 GC3	Section: 100-200 cm
Date: 13-08-2015	Described by: HJS

General remarks:



0-40 cm: vaguely mottled grayish brown silty clay
Open or partially filled burrows 0.5-1 cm ⌀ at 10, 23, 37, 38 cm
Backfilled subhorizontal burrow 0.5-1 cm ⌀ at 22, 32 cm

40-60 cm: distinctly mottled lighter and darker grayish brown silty clay. Large open burrow 1-2 cm ⌀ with mm size fecal pellets at 57-59 cm. Backfilled burrow 0.5 cm at 40 cm.

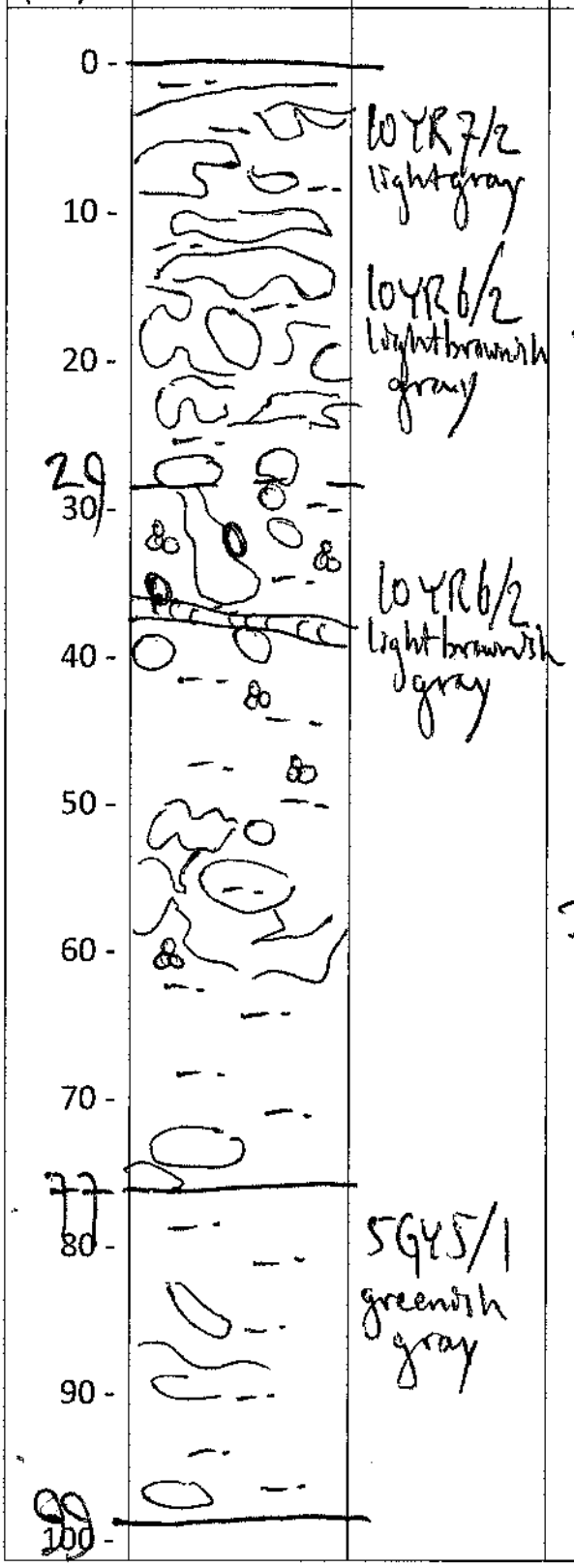
60-93 cm: Vaguely mottled to homogeneous grayish brown silty clay. Open or partially filled burrows 0.5 cm ⌀ at 67, 82 cm. Backfilled subhorizontal burrow 1 cm ⌀ at 61 cm. Gradual transition to:

93-100 cm: mottled grayish brown silty clay

SO242/1 gravity core description 165-264 cm

Core: SO242-1 84 GC3	Section: 200-300 cm
Date: 13-08-2015	Described by: HJS

General remarks:



0-29 cm: distinctly mottled light gray and light brownish gray silty clay. Gradual transition to:

29-77 cm: mottled light brownish gray silty clay, distinctly lighter mottles in upper part, less distinct further down. Open burrows 0.5 cm ⌀ at 33, 37 cm, backfilled subhorizontal burrow 1 cm ⌀ at 38-40 cm. Very sharp and distinct boundary to:

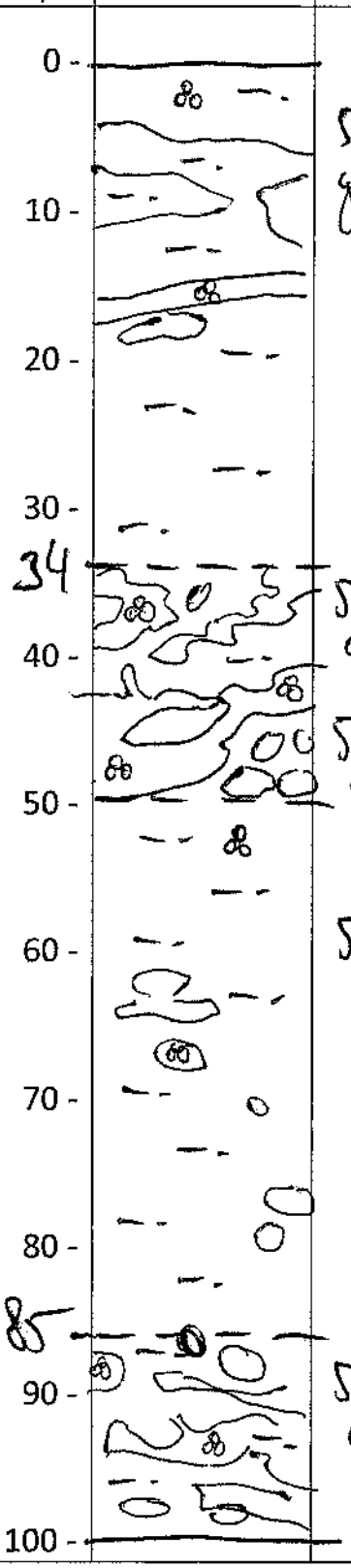
77-99 cm: Vaguely mottled greenish gray silty clay

SO242/1 gravity core description

264 - 364 cm

Core: SO242-1 84GC3	Section: 300 - 400 cm
Date: 13-08-2015	Described by: HJS

General remarks:



0-34 cm: homogeneous to vaguely mottled greenish gray silty clay with some patches with foram's Distinct transition to:

34-50 cm: distinctly darker and lighter gray mottled silty clay some patches with foraminifera

50-85 cm: Vaguely mottled and cloudy to homogeneous gray silty clay, in upper part some patches with forams. Gradual transition to:

85-100 cm: Mottled to cloudy gray silty clay with some foraminifera. Partially filled burrow 0.5 cm Ø at 85 cm

SO242/1 gravity core description

364-463 cm

Core: SO242-1 84 GC3	Section: 400-500 cm
Date: 13-08-2015	Described by: HJS

General remarks:

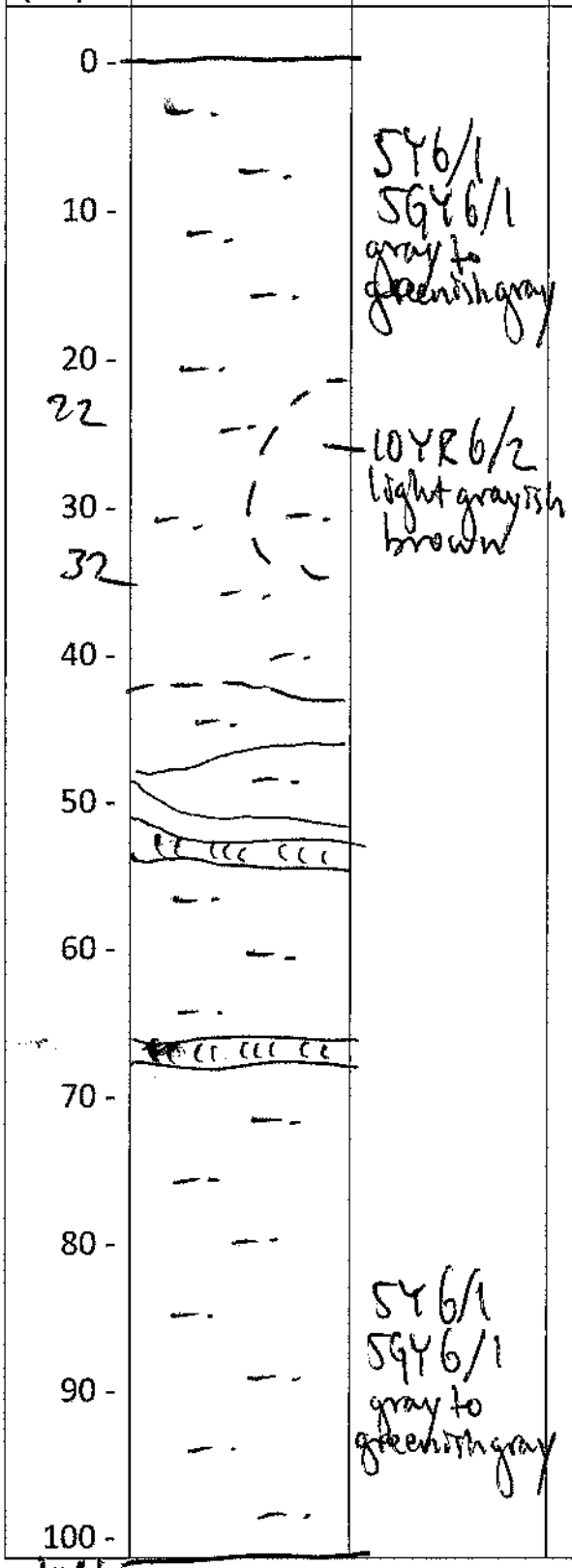
Depth (cm)	Lithology	Colour	Description
0		5Y 5/1 gray	0-41 cm: cloudy to distinctly mottled lighter and darker gray silty clay with some patches with foraminifera
10		5Y 6/1 gray	Gradual transition to:
20			41-99 cm: Homogeneous gray to greenish gray silty clay, in upper part vaguely mottled.
30			
40			
41			
50			
60		5Y 5/1 gray	
70			
80			
90		5Y 5/1 5GY 5/1 greenish gray	
99			
100			

SO242/1 gravity core description

463-567cm

Core: SO242-1 84 GC3	Section: 500-600cm
Date: 13-08-2015	Described by: HJJ

General remarks:

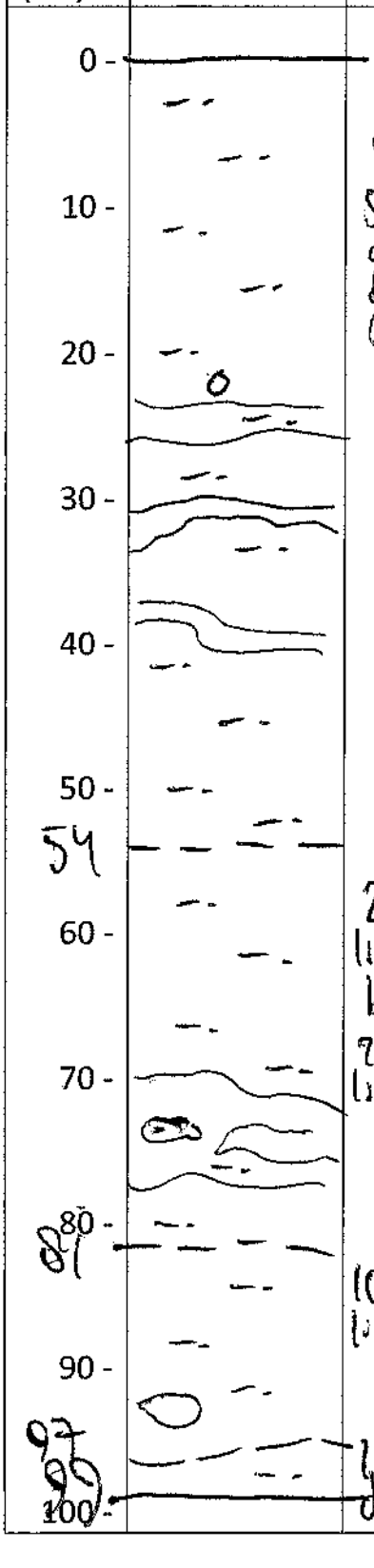


SO242/1 gravity core description

567-666 cm

Core: SO242-1 84GC3	Section: 600-700 cm
Date: 13-08-2015	Described by: MJS

General remarks:



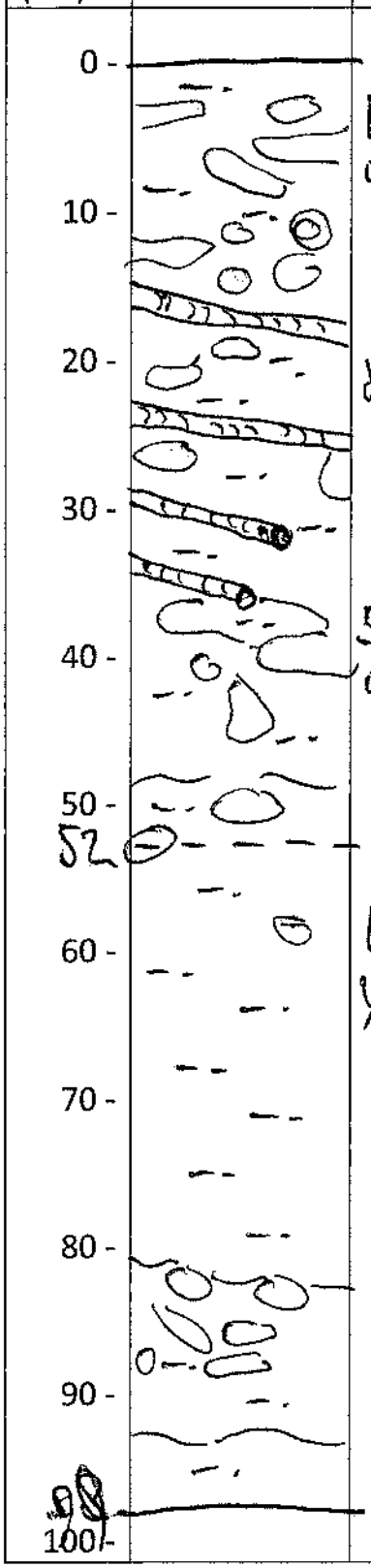
Depth (cm)	Lithology	Colour	Description
0-54		5Y 6/1 5GY 6/1 gray to greenish gray	0-54 cm: Homogeneous to vaguely cloudy gray to greenish gray silty clay. Open burrow 0-5 cm Ø at 22 cm. Gradual transition to:
54-81		2.5Y 6/4 light yellow brown 2.5Y 6/2 light brownish gray	54-81 cm: Vaguely cloudy light yellowish brown to light brownish gray silty clay. Gradual transition to:
81-97		10YR 6/4 light yellowish brown	81-97 cm: Light yellowish brown silty clay.
97-100		10YR 4/4 dark yell. brown	97-99 cm: Dark yellowish brown silty clay.

SO242/1 gravity core description

666-765 cm

Core: SO242-1 84 GC 3	Section: 700 - 800 cm
Date: 13-08-2015	Described by: HJS

General remarks:



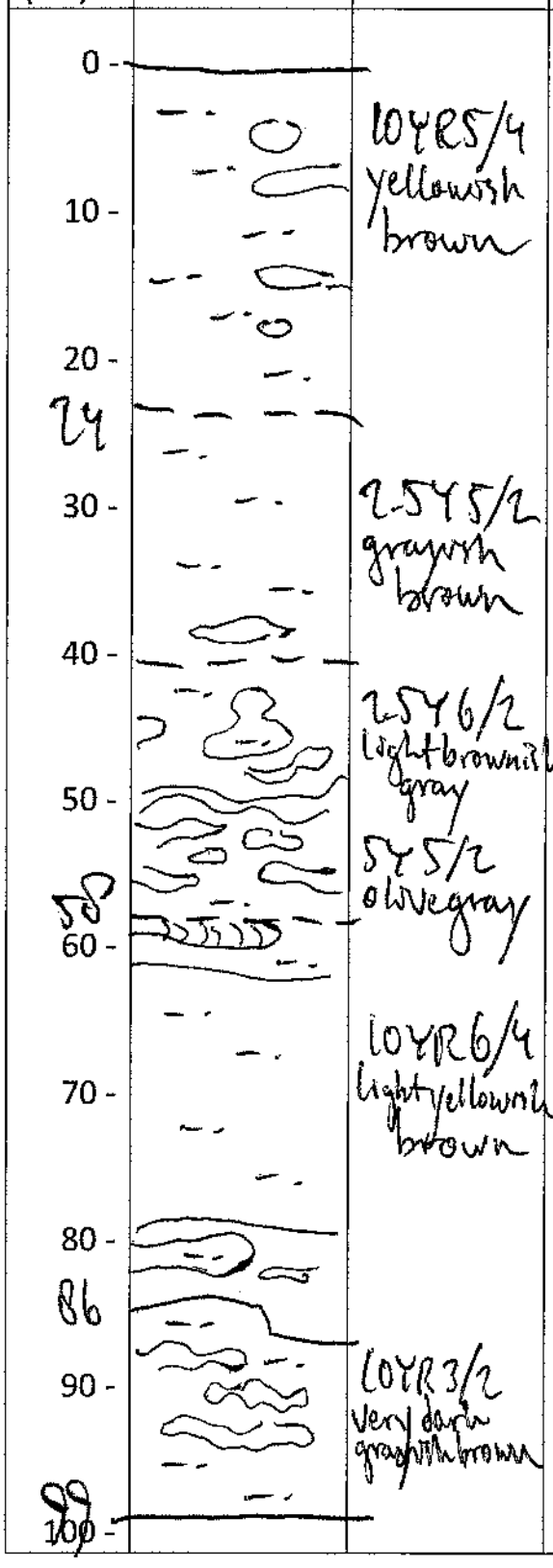
Depth (cm)	Lithology	Colour	Description
0 - 52		10YR 3/4 dark yellowish brown; 10YR 4/4 dark yellowish brown; 5YR 3/2 dark reddish brown	0-52 cm = Mottled dark yellowish to dark reddish brown silty clay with some lighter yellowish brown patches. Backfilled subhorizontal burrows 0.5 cm ø at 17-19, 22-24, 29-32, 34-36 cm, the deepest two with open end in which min-sized fecal pellets are visible.
52 - 99		10YR 5/4 yellowish brown	52-99 cm: Mottled to cloudy yellowish brown silty clay

SO242/1 gravity core description

765-864 cm

Core: SO242-1 84GC3	Section: 800-900 cm
Date: 13-08-2015	Described by: HJS

General remarks:



0-24 cm: homogeneous to vaguely mottled yellowish brown silty clay. Gradual transition to:

24-40 cm: Vaguely cloudy grayish brown silty clay. Gradual transition to:

40-58 cm: Mottled to cloudy light brownish gray and olive gray silty clay.

58-86 cm: Homogeneous light yellowish brown silty clay, turning darker brown below 84 cm. Backfilled horizontal burrow 0.5-1 cm ø at 59 cm. Sharp colour boundary at:

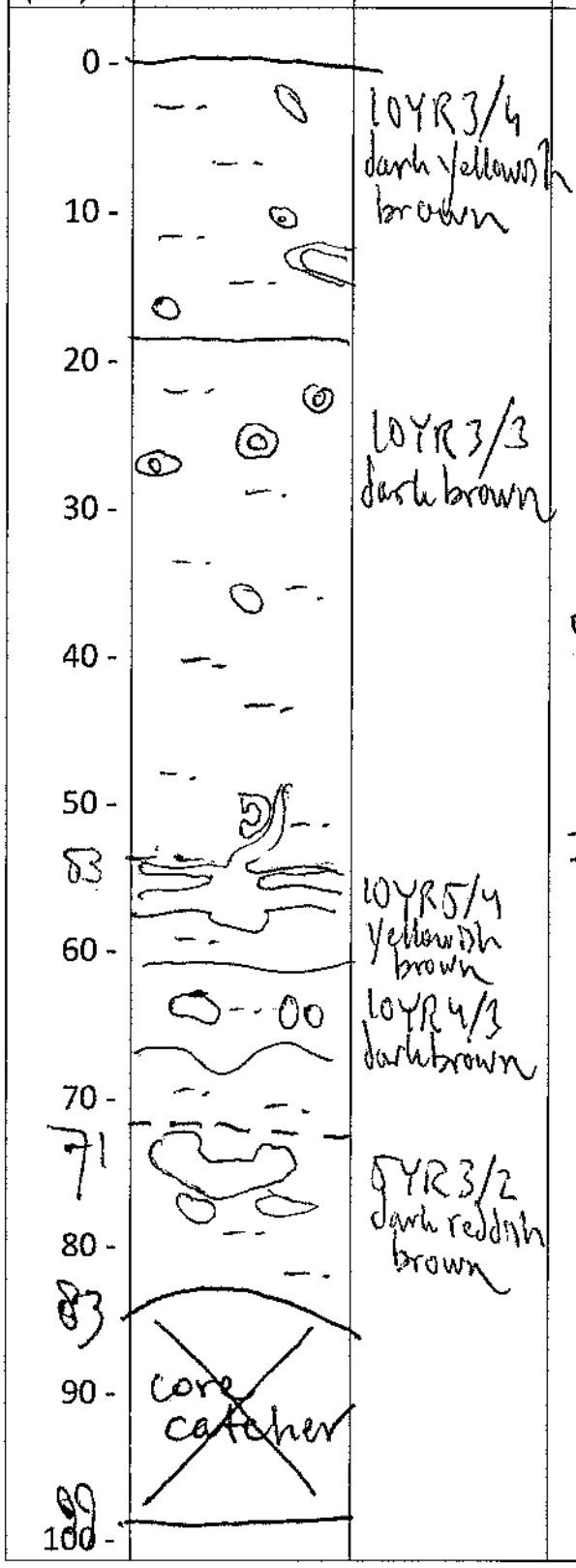
86-99 cm: Very dark grayish brown and lighter yellowish brown cloudy silty clay.

SO242/1 gravity core description

864-947 cm

Core: SO242-1 84 GC3	Section: 900 - 1000 cm
Date: 13-08-2015	Described by: HJS

General remarks:



Depth (cm)	Lithology	Colour	Description
0 - 53		10YR3/4 dark yellowish brown	0 - 53 cm: Vaguely mottled dark yellowish brown to dark brown silty clay. Yellowish brown rounded to oval patches ~ 1 cm Ø with dark core at 3, 10, 23, 26 and 49 cm. More cloudy in lower part, and gradual transition to:
53 - 71		10YR5/4 yellowish brown 10YR4/3 dark brown	53 - 71 cm: Mottled to cloudy dark brown with yellowish brown silty clay.
71 - 83		5YR3/2 dark reddish brown	71 - 83 cm: Dark reddish brown mottled silty clay
83 - 100	core catcher		

SO242/1 gravity core description

0-41 cm

Core: SO242-1 89GC 4	Section: 0-100 cm
Date: 14-08-2015	Described by: HJS

General remarks: top ~ 10 cm of soft brown mud, including small Mn-nodules, slumped out during core handling on deck. Preserved in working half of split core

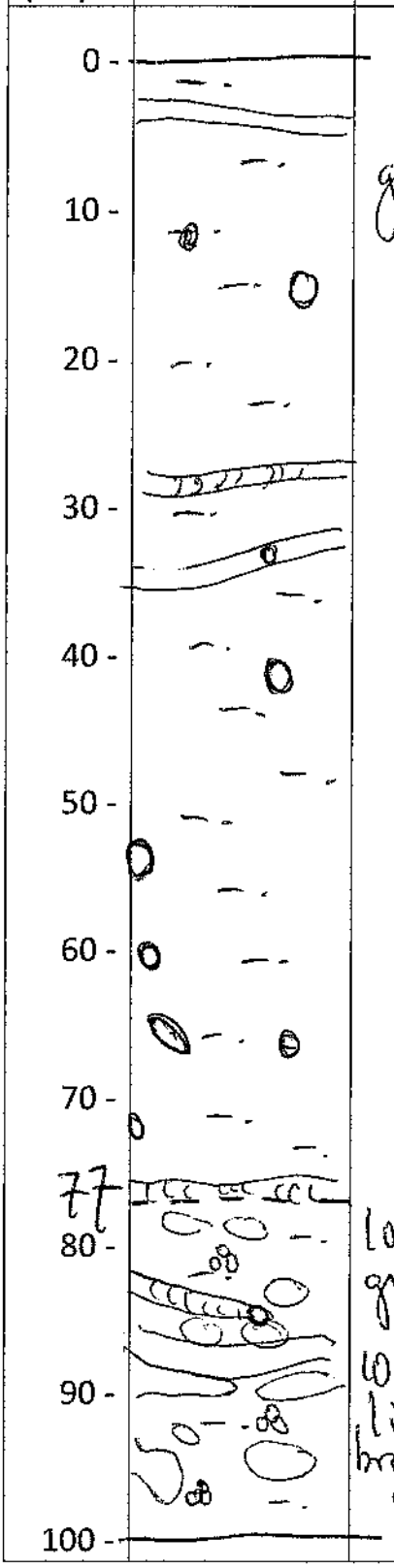
Depth (cm)	Lithology	Colour	Description
0	Slumped out	5YR 3/2 dark reddish brown	~ 0-10 cm: Soft dark reddish brown silty clay, most of it slumped out
10			~ 10-19 cm: Mottled dark reddish brown and grayish brown silty clay
19 / 20		10YR 5/2 grayish brown	19-41 cm: Homogeneous to variably mottled grayish brown silty clay with foraminifera. Open burrow 1 cm Ø at 38 cm.
30			
40			
41			
50			
60			
70			
80			
90			
100			

SO242/1 gravity core description

41 - 141 cm

Core: SO242-1 89 GC 4	Section: 100 - 200 cm
Date: 14-08-2015	Described by: HDS

General remarks:



0 - 77 cm: Homogeneous to vaguely mottled grayish brown silty clay. Open or partially filled burrows 0.5 - 1 cm ⌀ at 12, 17, 32, 38, 42, 59, 60, 66 cm. Subhorizontal backfilled burrows 0.5 - 1 cm ⌀ at 28, 76 cm.

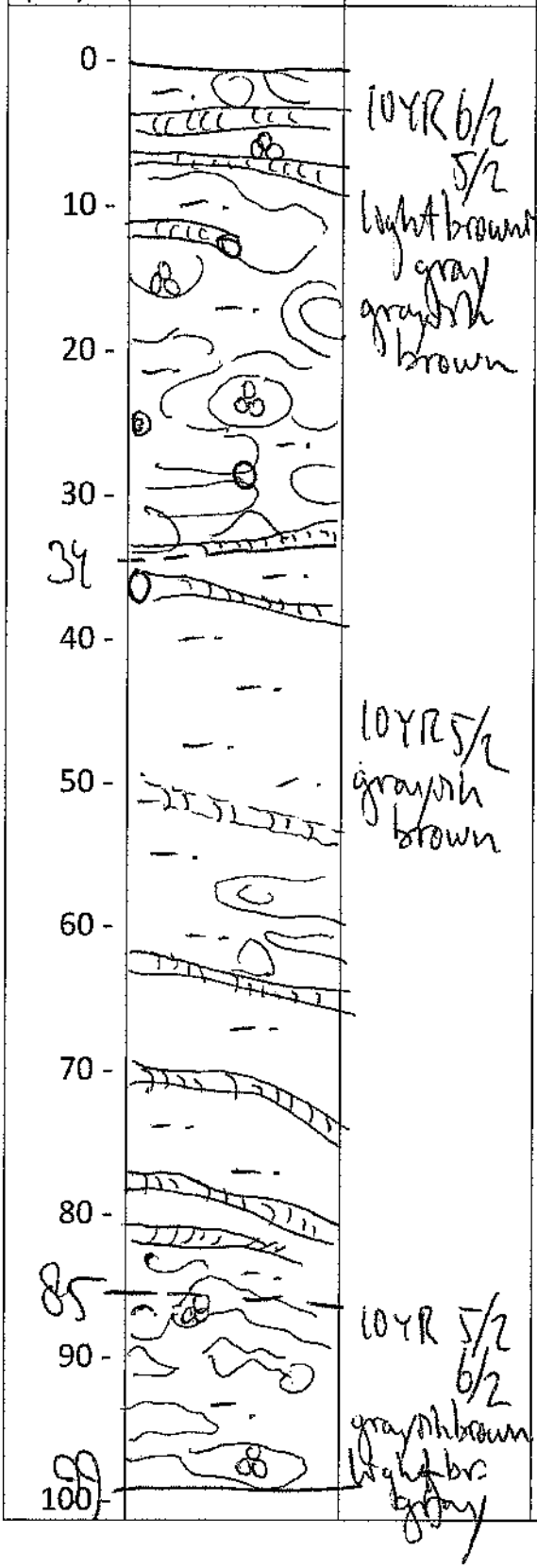
77 - 100 cm: Distinctly mottled grayish brown and light brownish gray silty clay with a few foraminifera. Backfilled subhorizontal burrow 0.5 cm ⌀ at 82 cm.

SO242/1 gravity core description

141 - 244 cm

Core: SO 242-1 89 GC 4	Section: 200 - 300 cm
Date: 14-08-2015	Described by: HJS

General remarks:



Description

0 - 34 cm = Distinctly mottled grayish brown and light brownish gray silty clay with some foraminifera. Backfilled subhorizontal burrows 0.5 - 1 cm Ø at 4, 6-7 cm 34 cm Open burrows 0.5 - 1 cm Ø at 25, 28 cm

34 - 85 cm = Homogeneous and mottled grayish brown silty clay. Backfilled subhorizontal burrows 1 cm Ø at 35-37, 50-53, 63-65, 70-73, 78, 81 cm

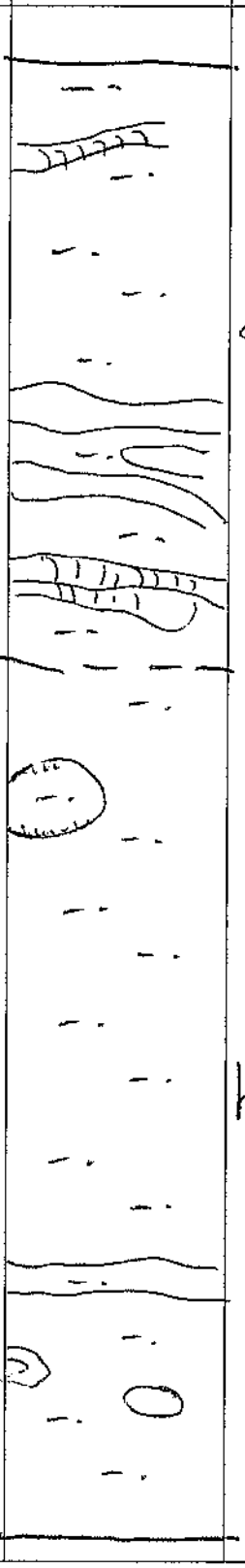
85 - 99 cm: Distinctly mottled light and darker grayish brown silty/clay with some foraminifera

SO242/1 gravity core description

241 - 341 cm

Core: SO242-1 89 GC 4	Section: 300 - 400 cm
Date: 14-08-2015	Described by: HJS

General remarks:

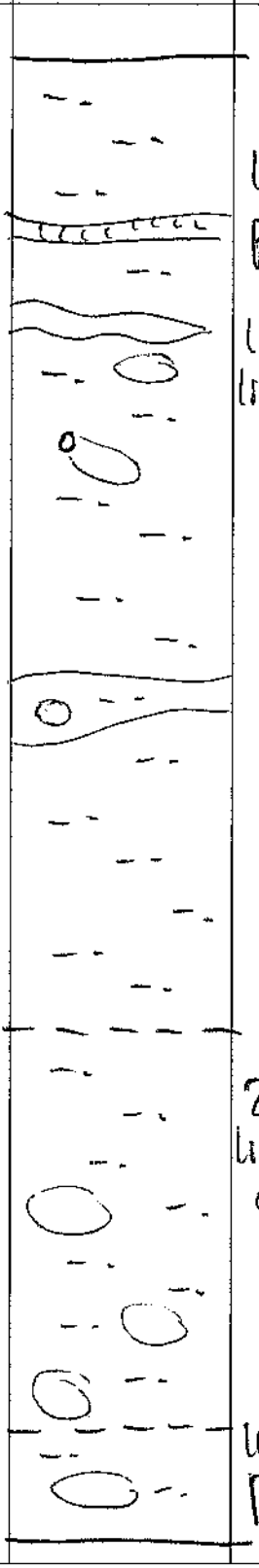
Depth (cm)	Lithology	Colour	Description
0 - 100		10YR 5/2 6/2 light br. gray to grayish brown 10YR 6/3 pale brown 10YR 6/2 light brownish gray	0-40 cm: Vaguely mottled light brownish gray to grayish brown silty clay. Backfilled burrows 1 cm ø at 5cm 28 cm?, 34-36 cm. Gradual transition to: 40-100 cm: Vaguely cloudy to mottled pale brown to light brownish gray silty clay. Large oval patch with Fe oxide? rim at 48-51 cm

SO242/1 gravity core description

341-441 cm

Core: SO 242-1 89 GC 4	Section: 400 - 500 cm
Date: 14-08-2015	Described by: HDS

General remarks:

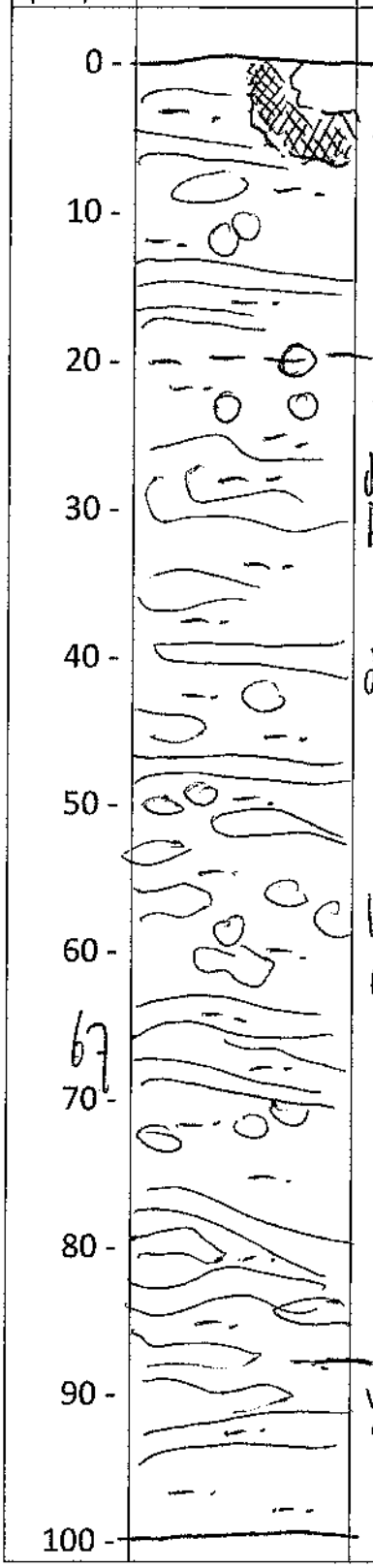
Depth (cm)	Lithology	Colour	Description
0 - 100		10YR 6/3 pale brown / 10YR 6/2 light brownish gray / 2.5Y 6/2 light brownish gray / 10YR 6/3 pale brown	0 - 100 cm: Vaguely mottled to cloudy pale brown and light brownish gray silty clay, faintly greenish from 65-92 cm. Open burrow 0.5 cm ⌀ at 25 cm. Backfilled subhorizontal burrow 1 cm ⌀ at 11 cm.

SO242/1 gravity core description

441-541 cm

Core: SO242-1 89 GC 4	Section: 500-600 cm
Date: 14-08-2018	Described by: HJS

General remarks:



Description

0-20 cm: Vaguely mottled pale brown silty clay. Round patch of black gritty material, possibly desintegrated Mn nodule? Gradual transition to:

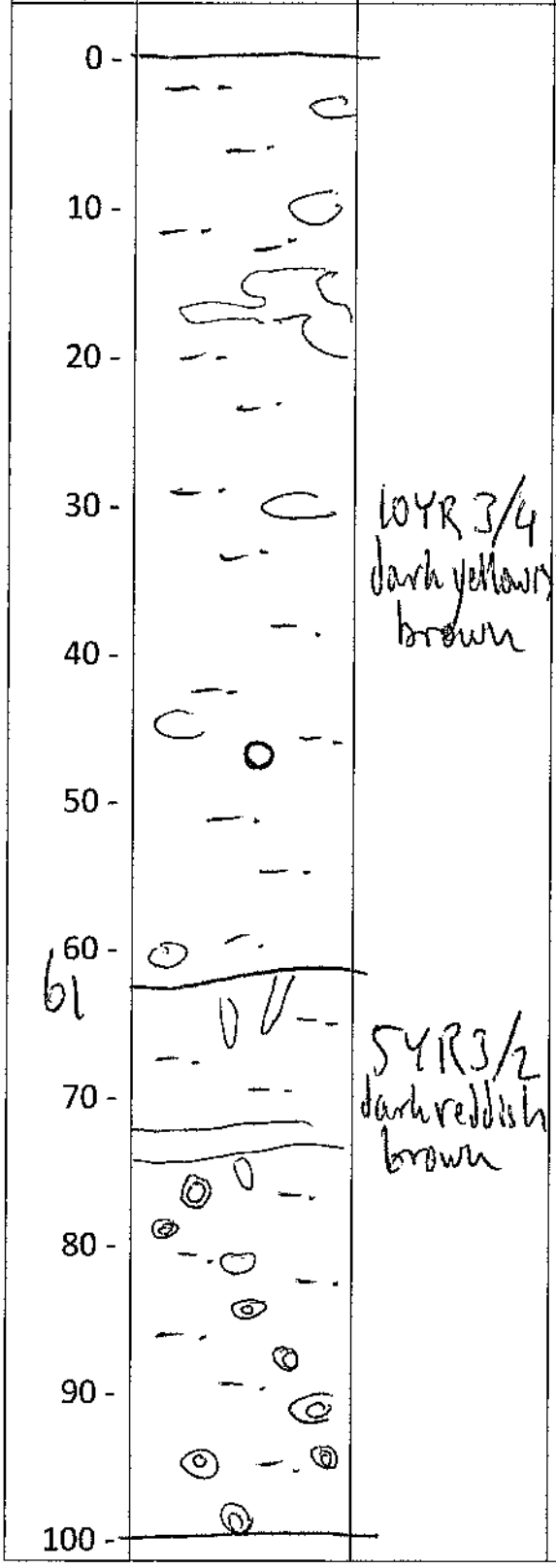
20-100 cm: Mottled to cloudy dark reddish and yellowish brown turning to dark brown with cloudy patches of yellowish brown from 67 cm downward. Subhorizontal bands ~1 cm thick. Common, possibly representing backfilled burrows?

SO242/1 gravity core description

541-641 cm

Core: SO242-1 89GC4	Section: 600-700 cm
Date: 14-08-2015	Described by: HDS

General remarks:



0-61 cm: Vaguely mottled to cloudy dark yellowish brown silty clay with a few small cloudy patches of yellowish brown. Open burrow 0.5-1 cm ø at 46 cm. Sharp boundary to:

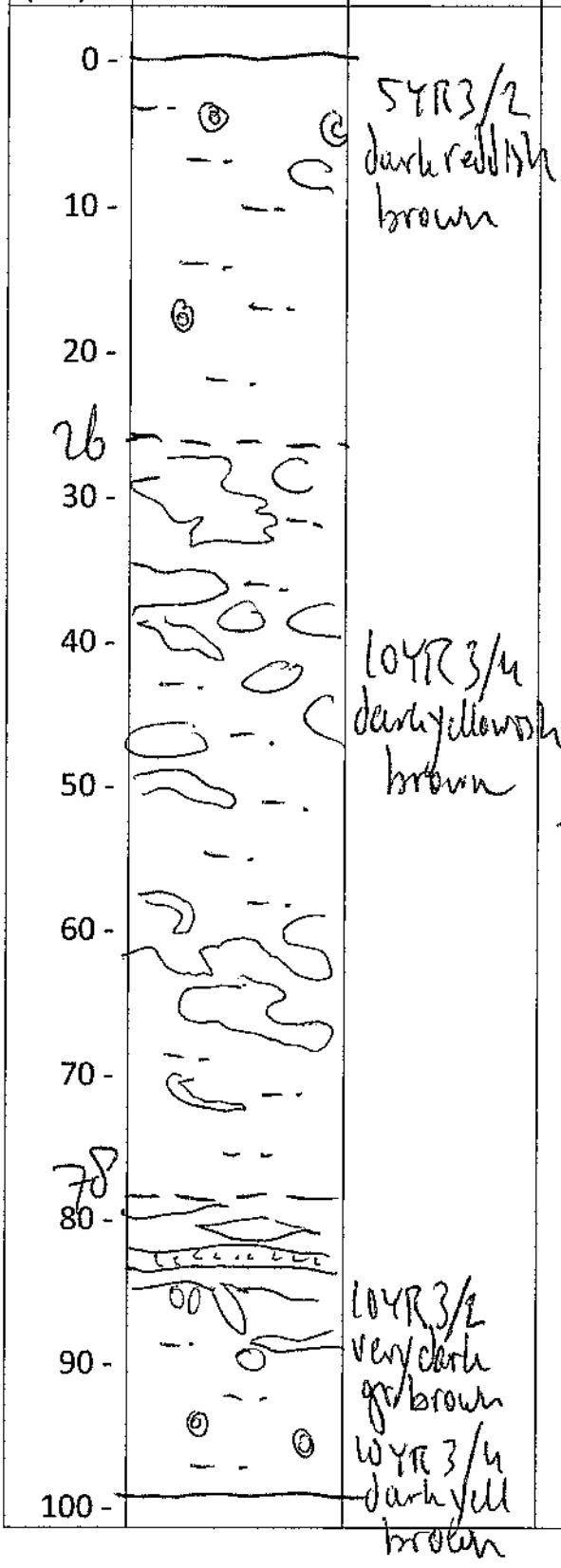
61-100 cm: Dark reddish brown silty clay with round to oval yellowish brown patches 0.5-1 cm ø with darker core at 73, 74, 77, 80, 82, 90, 93, 94, 99 cm.

SO242/1 gravity core description

641-741 cm

Core: SO242-1 89GC4	Section: 700-800 cm
Date: 14-08-2015	Described by: HDS

General remarks:



0-26 cm: Homogeneous dark reddish brown silty clay with occasional round spots 0.5-1 cm Ø of yellowish brown with darker core "hazelnuts"

26-78 cm: Mottled to cloudy dark yellowish brown silty clay with a few streaks of yellowish brown. Distinct irregular transition to:

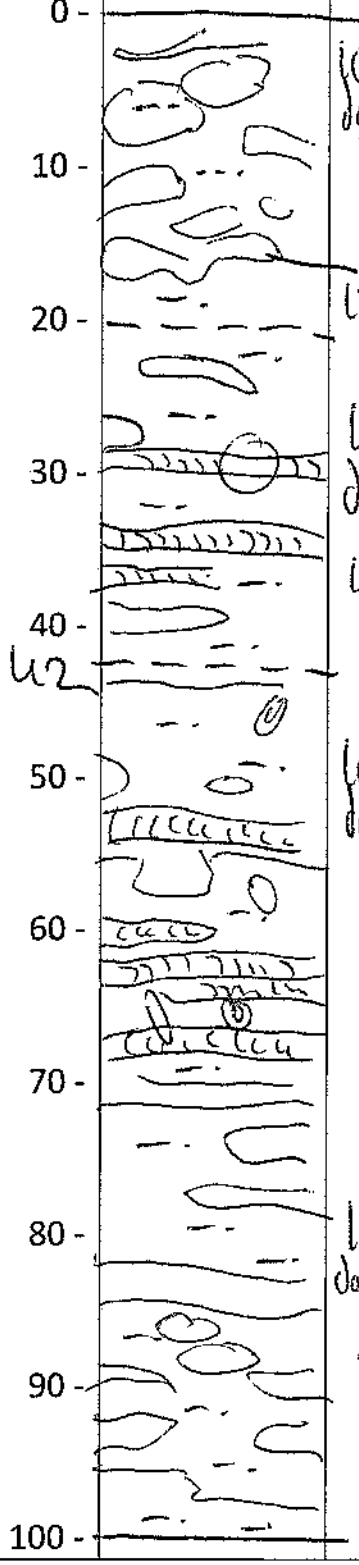
78-100 cm: Mottled dark yellowish brown and very dark grayish brown silty clay with a few round spots 0.5 cm in yellowish brown with darker core.
Backfilled horizontal burrow 0.5 cm Ø at 81 cm.

SO242/1 gravity core description

741-841 cm

Core:	SO 242-1 89 GC4	Section:	800-900 cm
Date:	14-08-2015	Described by:	HJS

General remarks:



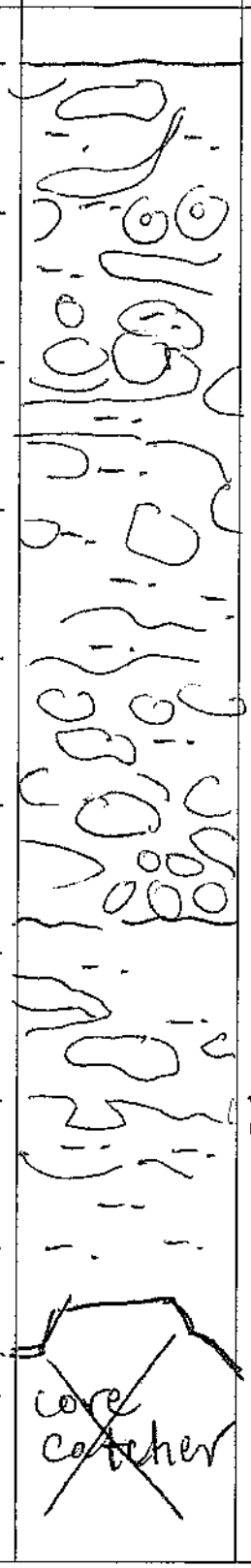
Depth (cm)	Lithology	Colour	Description
0-42		10YR 3/2 dark yellowish brown; 10YR 6/4 light yell. brown; 10YR 4/3 dark brown; 10YR 5/3 brown	0-20 cm: Mottled to cloudy dark yellowish brown silty clay with light yellowish brown patch at 15-17 cm. Gradual transition to: 20-42 cm: Slightly lighter than overlying unit, brown silty clay with dark brown elongate patches and distinct backfilled horizontal burrows ~1 cm Ø at 29, 33, 35 cm
42-100		10YR 3/3 dark brown; 10YR 4/4 dark yellowish brown	42-100 cm: Mottled varicoloured dark brown and dark yellowish brown silty clay. Backfilled horizontal burrows 1 cm Ø at 42, 54, 60, 63, 64, 67 cm

SO242/1 gravity core description

841-928 cm

Core: SO242-1 89 GC 4	Section: 900 - 1000 cm
Date: 14-08-2015	Described by: HJS

General remarks:

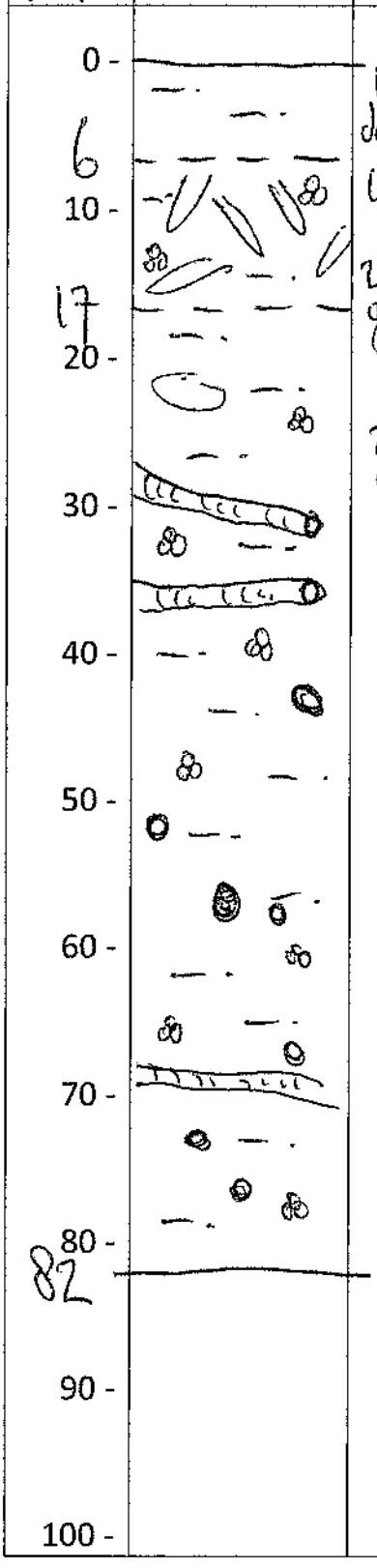
Depth (cm)	Lithology	Colour	Description
0 - 100		10YR3/4 dark brown 10YR5/3 brown 10YR4/3 dark brown 10YR5/3 brown 10YR6/4 light yellowish brown	0-58cm: Distinctly mottled brown and dark brown silty clay with occasional lighter yellowish brown patches 58-87cm: Slightly lighter coloured than above, distinctly mottled brown and light yellowish brown silty clay with a few lighter yellowish brown patches

SO242/1 gravity core description

0-82 cm

Core: SO242-1 100 GC5	Section: 0 - 100 cm
Date: 16-08-2015	Described by: HDJ

General remarks: very soft watery mud at top ~ 10 cm of core slumped out during core handling on deck



0-6 cm: Soft dark brown silty clay

6-17 cm: Mottled dark brown and grayish brown silty clay with foraminifera

17-82 cm: Vaguely mottled grayish brown silty clay with foraminifera. Open burrows or partially filled ~0.5 cm Ø at 42, 51, 59, 67, 73, 76 cm

Larger burrow 1-2 cm Ø packed with 3 mm long fecal pellets at 58-59 cm

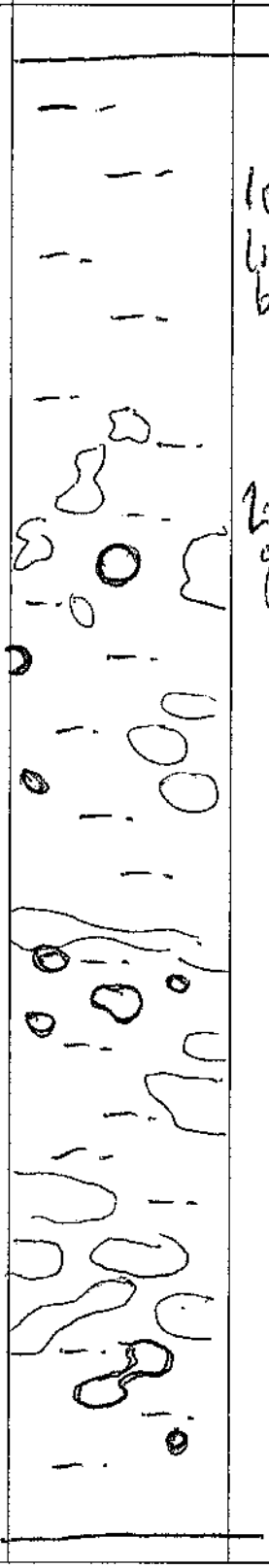
Backfilled subhorizontal burrows 0.5-1 cm Ø at 30-32, 35, 69 cm, the upper two with open end.

SO242/1 gravity core description

82-182 cm

Core: SO242-1 100GC5	Section: 100 - 200 cm
Date: 16-08-2015	Described by: HJS

General remarks:

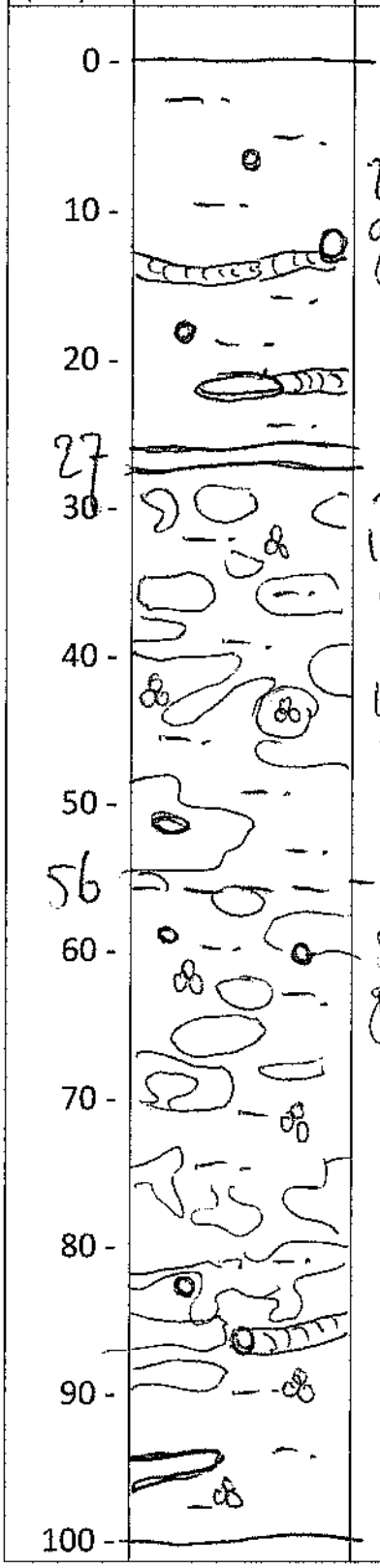
Depth (cm)	Lithology	Colour	Description
0 - 100		10YR 6/2 light brownish gray / 2.5Y 5/2 grayish brown	0-100 cm: Vaguely and more distinctly mottled light brownish gray and grayish brown silty clay. Open or partially filled burrows 0.5-1 cm Ø at 32, 41, 48, 60-66, 87-93 cm

SO242/1 gravity core description

182-282 cm

Core: SO242-1 100GC5	Section: 200-300 cm
Date: 16.08.2015	Described by: HDS

General remarks:



0-27 cm: Vaguely mottled grayish brown silty clay. Open or partially filled burrows 0.5 cm ø at 8, 18 cm. Backfilled horizontal burrow 0.5 cm ø at 13, 21 cm, with open end.

27-56 cm: Lighter coloured distinctly mottled light brownish gray and light gray silty clay with some foraminifera. Open burrow 0.5 cm ø at 51 cm. Gradual transition to:

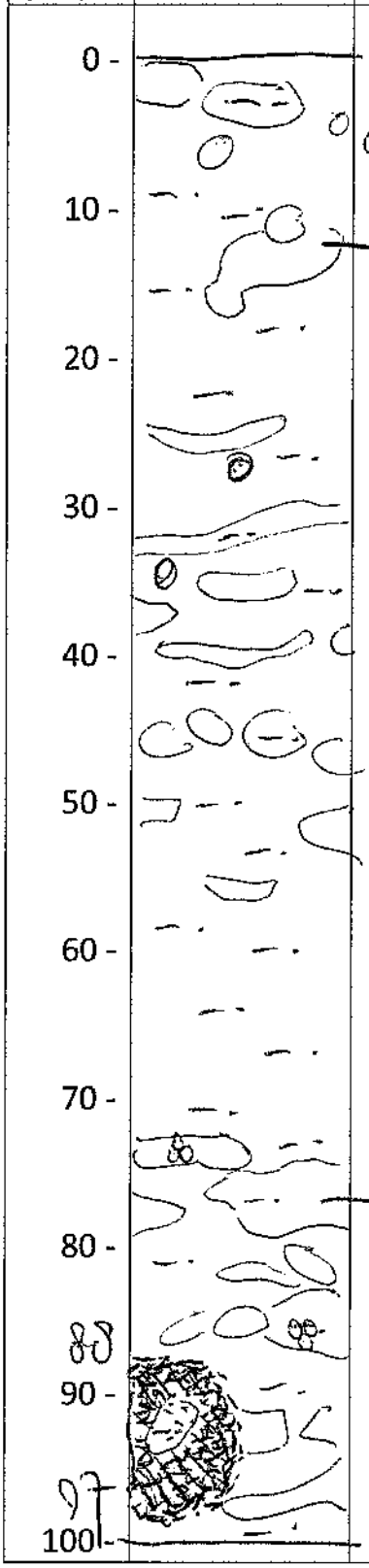
56-100 cm: Mottled greenish gray to gray silty clay with foraminifera. Open burrows 0.5 cm ø at 59, 60, 83, 95 cm. Backfilled subhorizontal burrow 0.5-1 cm ø with open end at 84-85 cm

SO242/1 gravity core description

282-382 cm

Core: SO 242-1 100 GC 5	Section: 300-400 cm
Date: 16-08-2015	Described by: HDS

General remarks:



0-100 cm: Mottled, cloudy to homogeneous greenish gray and lighter gray silty clay. Distinct lighter patches 0-15cm, Mottled to cloudy 25-55cm, Homogeneous 55-73cm, distinctly mottled 73-100cm.

88-97 cm: Large oval patch of dark green granular material, slightly lighter colour in centre of patch. Interpreted as decomposing Mn nodule

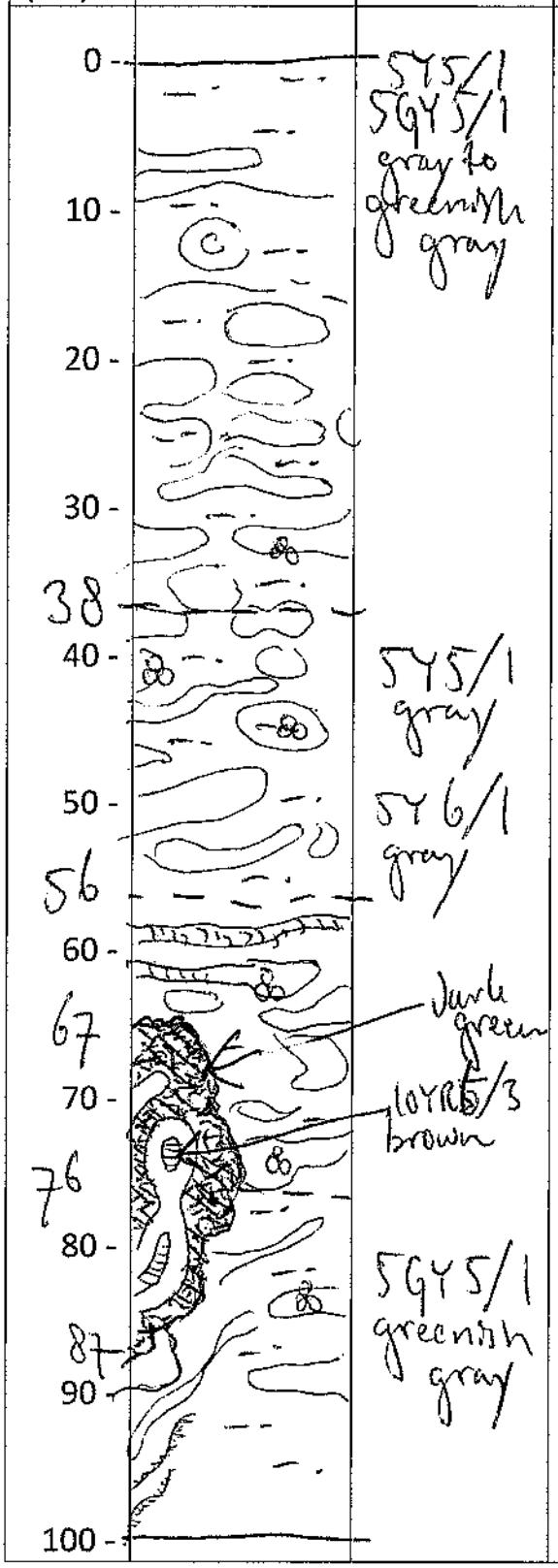
Open burrows 0.5cm Ø at 28, 34 cm

SO242/1 gravity core description

382-484 cm

Core: SO242-1 100 GC 5	Section: 400-500 cm
Date: 16-08-2015	Described by: HDJ

General remarks:



0-38 cm: Vaguely mottled gray to greenish gray silty clay

38-56 cm: Slightly darker mottled gray silty clay with some lighter gray patches.

56-76 cm: Lighter coloured mottled to cloudy lighter and darker gray to greenish gray silty clay Back filled burrows at 58, 60 cm

67-87 cm: Elongate patch of dark very dark green granular material with pale brown and dark brown silty clay in core of patch Interpreted as decomposing Mn nodule

76-100 cm: greenish gray silty clay with a few lighter coloured elongate patches. Some thin streaks of dark brown extending downward from green patch.

SO242/1 gravity core description

482-582

Core: SO242-1 100 GC 5	Section: 500-600 cm
Date: 16-08-2015	Described by: HJS

General remarks:

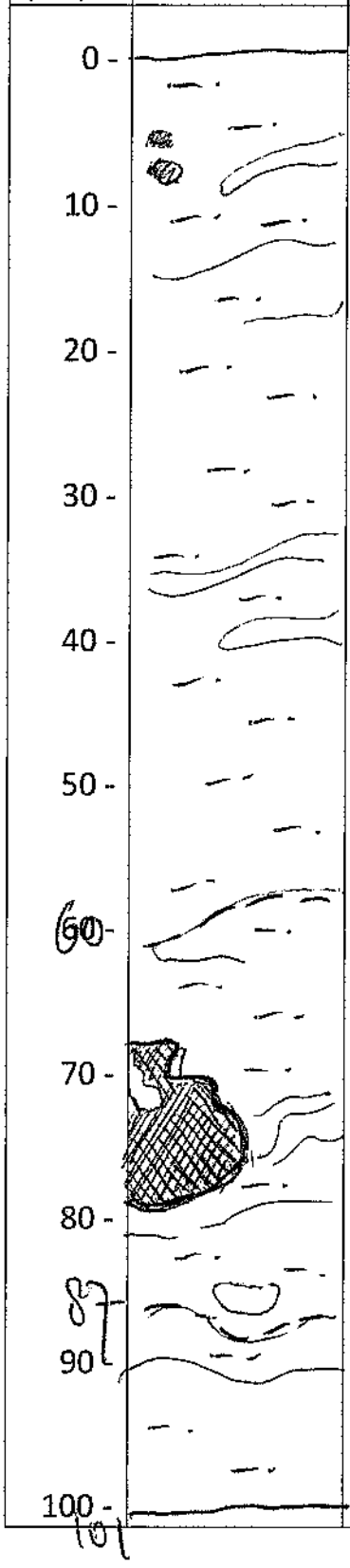
Depth (cm)	Lithology	Colour	Description
0		5GY 5/1 greenish gray	0-24/26 cm: Mottled greenish gray and gray silty clay with foraminifera in lighter patches. Sharp boundary to:
20		5Y 6/1 gray	24/26-56/63 cm: Homogeneous greenish gray to gray silty clay. Distinct yet gradual, irregular colour boundary to:
30		5GY 5/1 greenish gray	
40			
50		5Y 5/1 gray	56/63-69/76 cm: Homogeneous pale brown silty clay. Black oval shaped patch 1-2 cm Ø at 71 cm, probably Mn-nodule. Distinct yet gradual, irregular boundary to:
56/63 60		10YR 6/3 pale brown	
70		5Y 5/1 gray	69/76-86 cm: Homogeneous gray silty clay. Distinct yet gradual boundary to:
80			
86 90		10YR 6/3 pale brown	86-~~100~~ 99 cm: Homogeneous pale brown silty clay
100			

SO242/1 gravity core description

582-682 cm

Core: SO 242-1 100 GC 5	Section: 600 - 700cm
Date: 16-08-2015	Described by: HJS

General remarks:



0 - 60 cm: Homogeneous to vaguely cloudy greenish gray silty clay.
Two black Mn-oxide spots 0.5cm ø at 6, 7cm, possibly artefact, transported by cutting wire
Gradual colour transition to:

60 - 87 cm: Vaguely cloudy olive gray to bright brownish gray silty clay.
Solid black Mn-oxide nodule 2 cm ø at 70 - 72 cm. Some indurated brown sediment on upper part of nodule.
Gradual transition to:

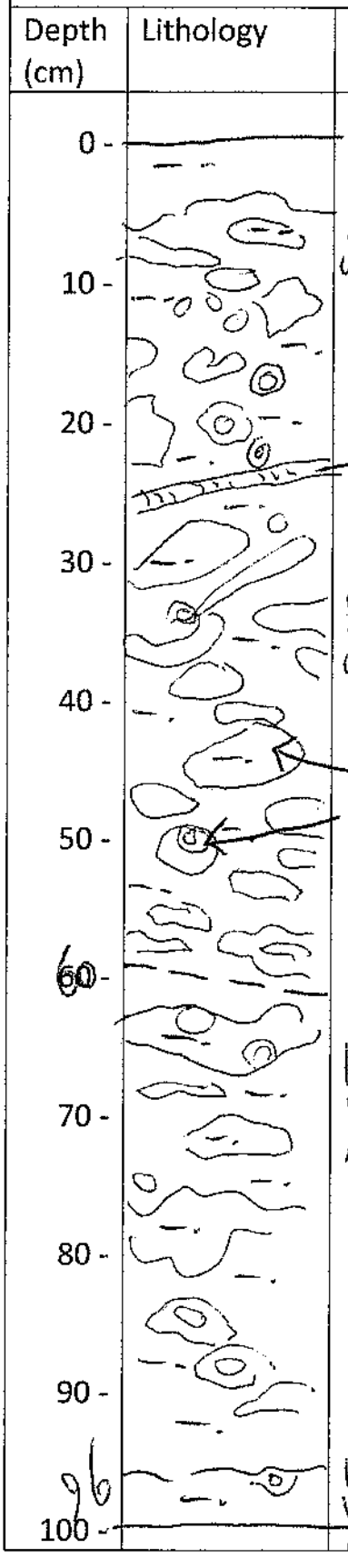
87 - 101 cm: Homogeneous yellowish brown silty clay

SO242/1 gravity core description

682-782cm

Core: SO 242-1 100 GC5	Section: 700-800 cm
Date: 16.08.2015	Described by: MdS

General remarks:



0-60 cm: Distinctly mottled dark yellowish brown to dark reddish brown silty clay with lighter coloured brown and yellowish brown patches. Subhorizontal backfilled burrow at 23-25 cm. Round to oval yellowish brown patches ~ 1 cm Ø with darker coloured core at 17, 23, 33, 49 cm

Distinct colour change at:

60-96 cm: Mottled to cloudy yellowish brown silty clay.

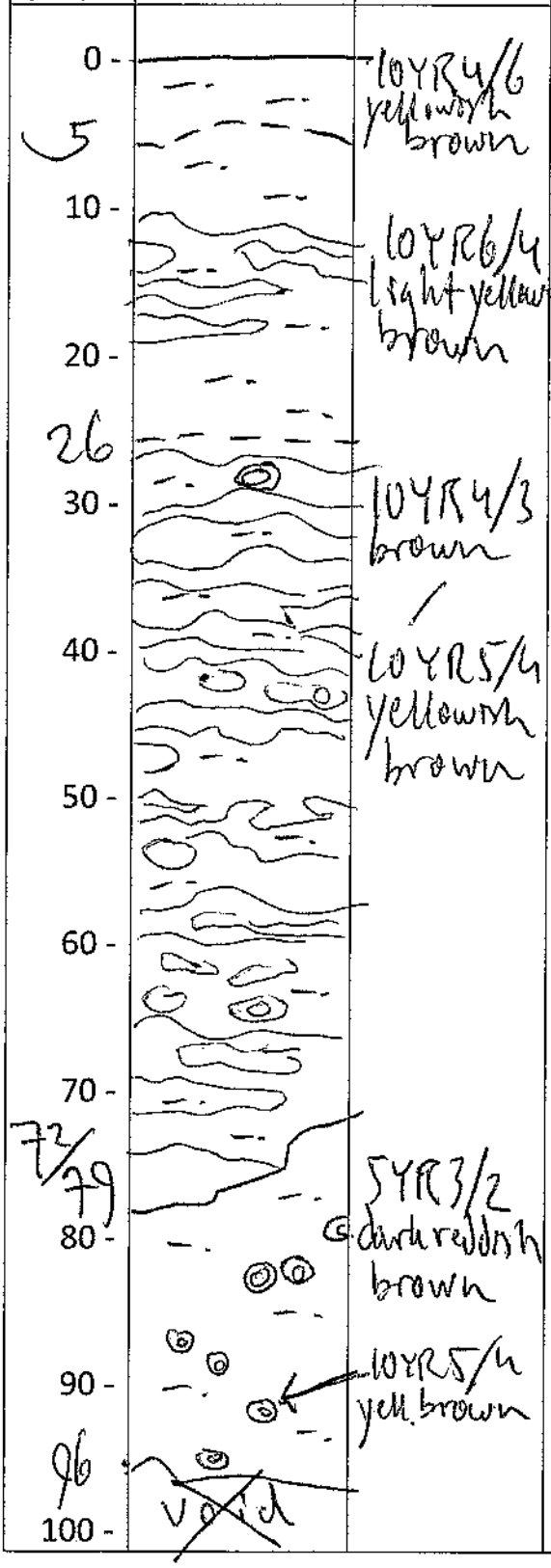
96-100 cm: Yellowish brown silty clay.

SO242/1 gravity core description

782-878 cm

Core: SO 242-1 100 GC 5	Section: 800-900 cm
Date: 16-08-2015	Described by: HJS

General remarks: lower ~20 cm of core cracked. Part of 10cm from core catcher recovered and placed back in bottom of lowest section



0-5 cm: Homogeneous yellowish brown silty clay
Sharp boundary to:
5-26 cm: Vaguely cloudy light yellowish brown silty clay
26-72/79 cm: Distinctly mottled brown and yellowish brown silty clay
Sharp irregular boundary to:
72/79-96 cm: Dark reddish brown silty clay with round to oval yellowish rings 0.5 cm Ø.
Different sections in crumbled lower part of core shows that rings are tubes in 3-D.

SO242/1 gravity core description

0-35 cm

Core: SO242-1 123 GC 6	Section: 0-100 cm
Date: 21-08-2015	Described by: HJS

General remarks: Top ~10 cm of soft brown mud slumped out during core handling on deck

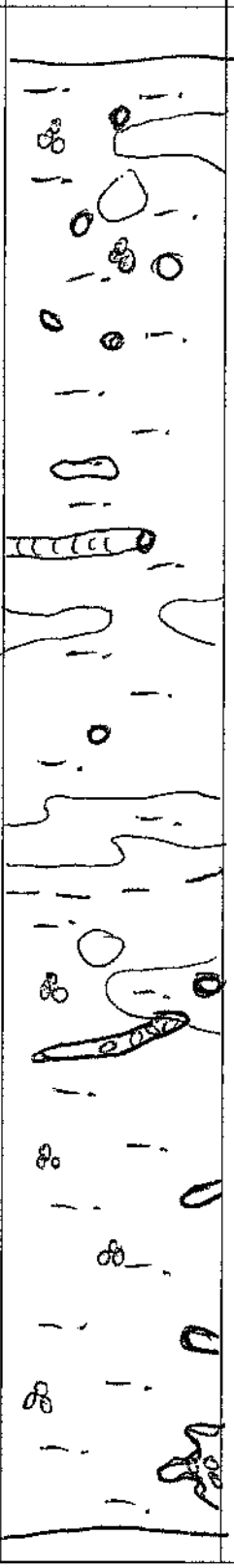
Depth (cm)	Lithology	Colour	Description
0 -	void		
5		10YR 3/3 dark brown	5-20 cm: Soft mottled dark brown and grayish brown silty clay
10 -		10YR 5/2 gr brown	
20 -		10YR 5/2 grayish brown	20-35 cm: Vaguely mottled grayish brown silty clay with foraminifera
30 -			
35			
40 -			
50 -			
60 -			
70 -			
80 -			
90 -			
100 -			

SO242/1 gravity core description

35-135 cm

Core: SO242-1 123 GC6	Section: 100-200 cm
Date: 21-08-2015	Described by: HdS

General remarks:



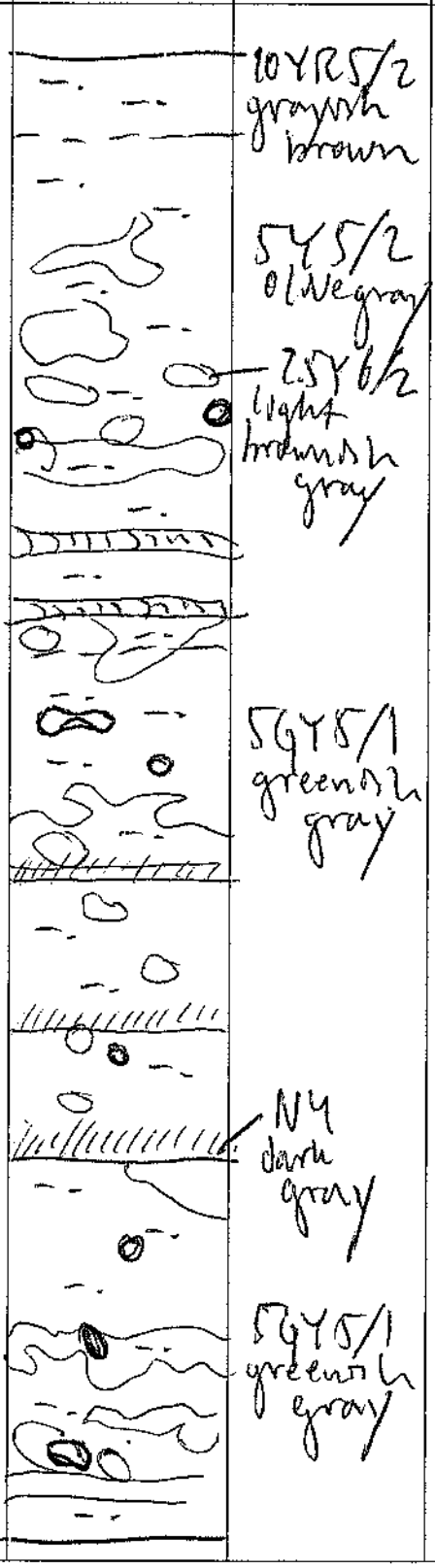
Depth (cm)	Colour	Description
0 - 57	10YR5/2 grayish brown	0-57 cm: Homogeneous to vaguely mottled grayish brown silty clay, in upper 15 cm with foraminifera. Open or partially filled burrows 0.5 cm ø at 4, 10, 12, 17, 18, 26, 46 cm. Backfilled horizontal burrow 1 cm ø at 32 cm, with open end.
57 - 100	2.5Y5/2 grayish brown	57-100 cm: Homogeneous to vaguely mottled grayish brown silty clay with foraminifera. Open or partially filled burrows 0.5-1 cm ø at 62, 66-68, 77, 88, 92-96 cm. Some burrows containing 2 mm long fecal pellets

SO242/1 gravity core description

135-235 cm

Core: SO242-1 123 GC 6	Section: 200 - 300 cm
Date: 4-08-2015	Described by: MdJ

General remarks:



0 - 6 cm: Grayish brown silty clay

6 - 40 cm: Mottled olive gray silty clay. Open burrows 0.5-1 cm ø at 23, 24 cm. Backfilled horizontal burrows 1 cm ø at 31, 36 cm. Gradual transition to:

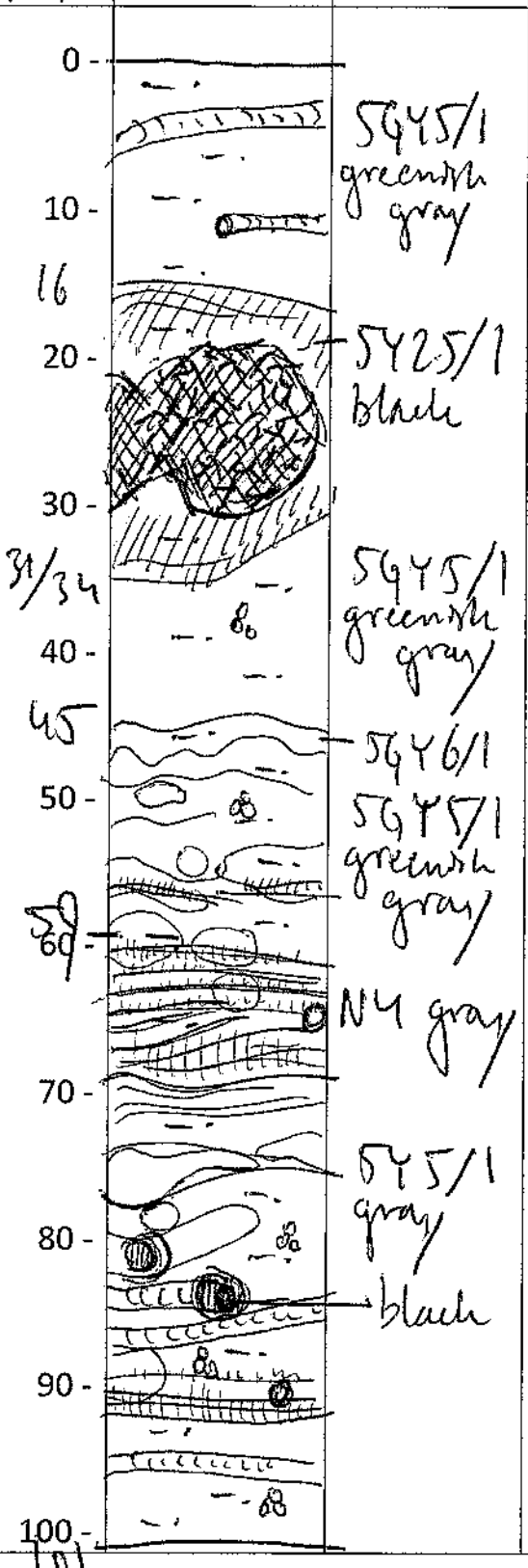
40 - 100 cm: Mottled to cleanly greenish gray silty clay; more distinctly mottled in lower 15 cm. Distinct gray bands ~ 1 cm thick with diffuse boundary at 54, 60 and 72 cm. Open or partially filled burrows 0.5-1 cm ø at 43, 48, 65, 79, 86, 94-95 cm.

SO242/1 gravity core description

235-336 cm

Core: SO 242-1 123 GC 6	Section: 300 - 400 cm
Date: 21-08-2015	Described by: HJS

General remarks:



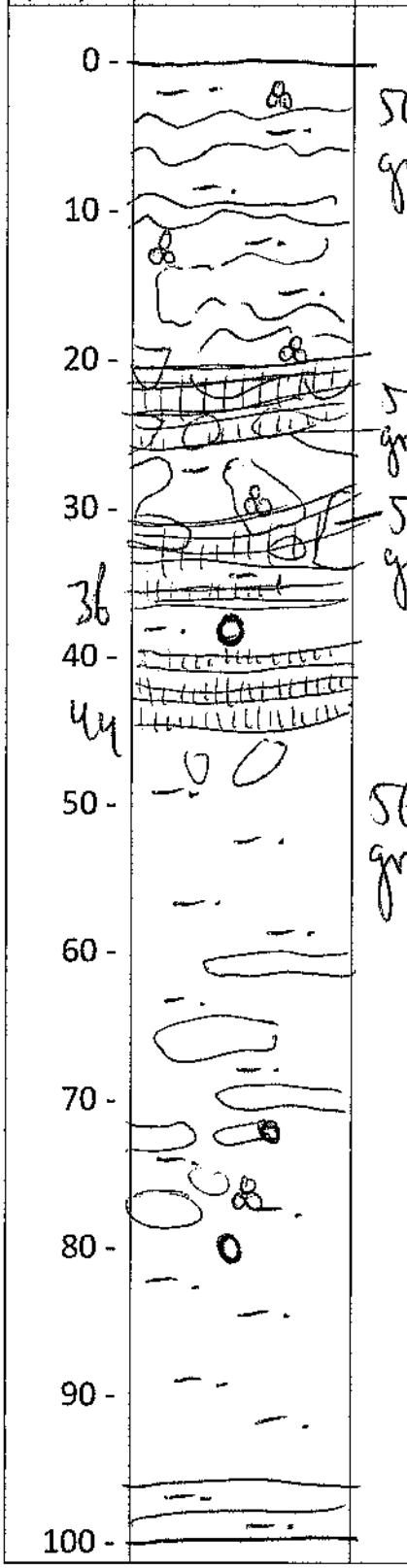
Depth (cm)	Lithology	Colour	Description
0 - 101			0-16 cm: Vaguely mottled greenish gray silty clay. Backfilled subhorz. burrow 0.5 cm Ø at 5, 11 cm 16-31/34 cm: Dark gray to black silty clay, with very dark green to black gritty material at 20-29 cm, probably disintegrated Mn nodule. 31/34-45 cm: Vaguely cloudy greenish gray silty clay with some foraminifera. 45-59 cm: Distinctly mottled lighter and darker greenish gray silty clay. 59-101 cm: Mottled gray silty clay with some foraminifera. Mm to cm-thick diffuse gray bands at 59-71 cm, 74-77, 88, 91-93 cm. Gray bands cross sedimentary structures. Open or partially filled burrows 0.5 cm Ø at 65, 90 cm. Backfilled burrows 1 cm Ø at 82, 83-85 cm. Round black patches at 80, 82 cm

SO242/1 gravity core description

336-436 cm

Core: SO 242-1 123 GC 6	Section: 400 - 500 cm
Date: 21-08-2015	Described by: HJS

General remarks:



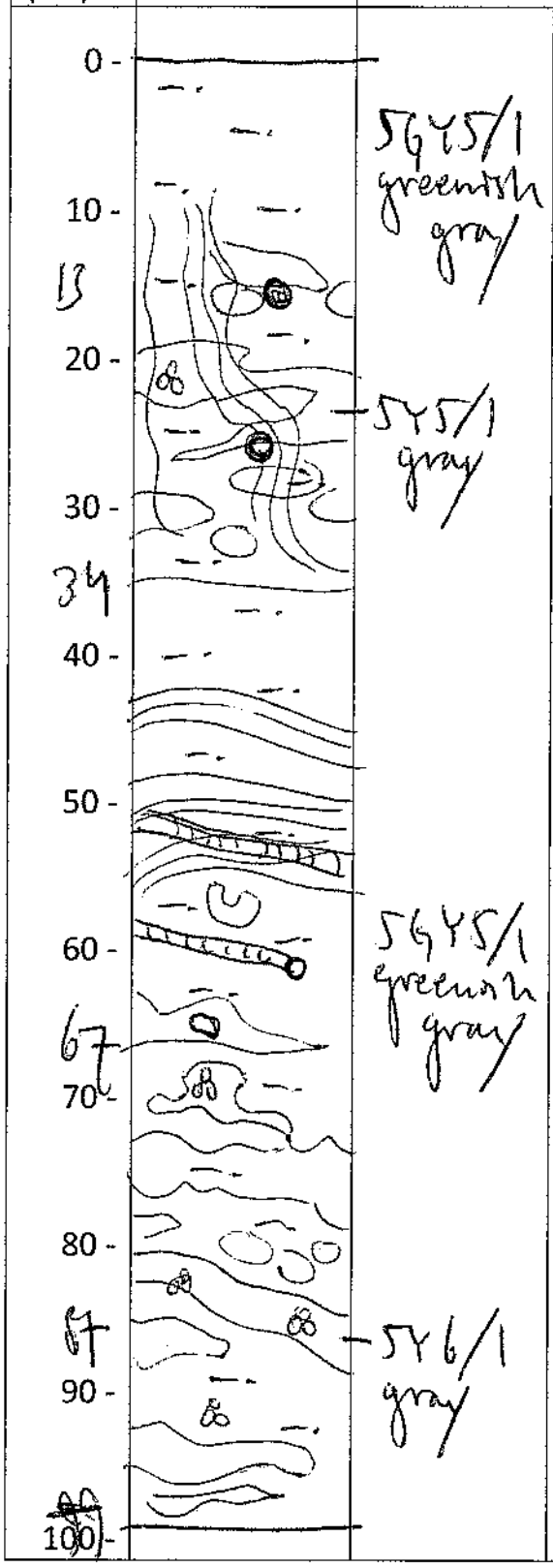
0-100 cm: Mottled to homogeneous greenish gray and gray silty clay with occasional foraminifera. Distinctly mottled with large lighter gray patches on greenish gray background from 20-36 cm. Numerous diffuse gray bands from 20-44 cm, crossing sedimentary structures. Large open burrow 1 cm Ø at 39 cm. Smaller burrows at 71, 80 cm.

SO242/1 gravity core description

436 - 536 cm

Core: SO242-1 123 GC 6	Section: 500 - 600 cm
Date: 21-08-2015	Described by: HDS

General remarks:



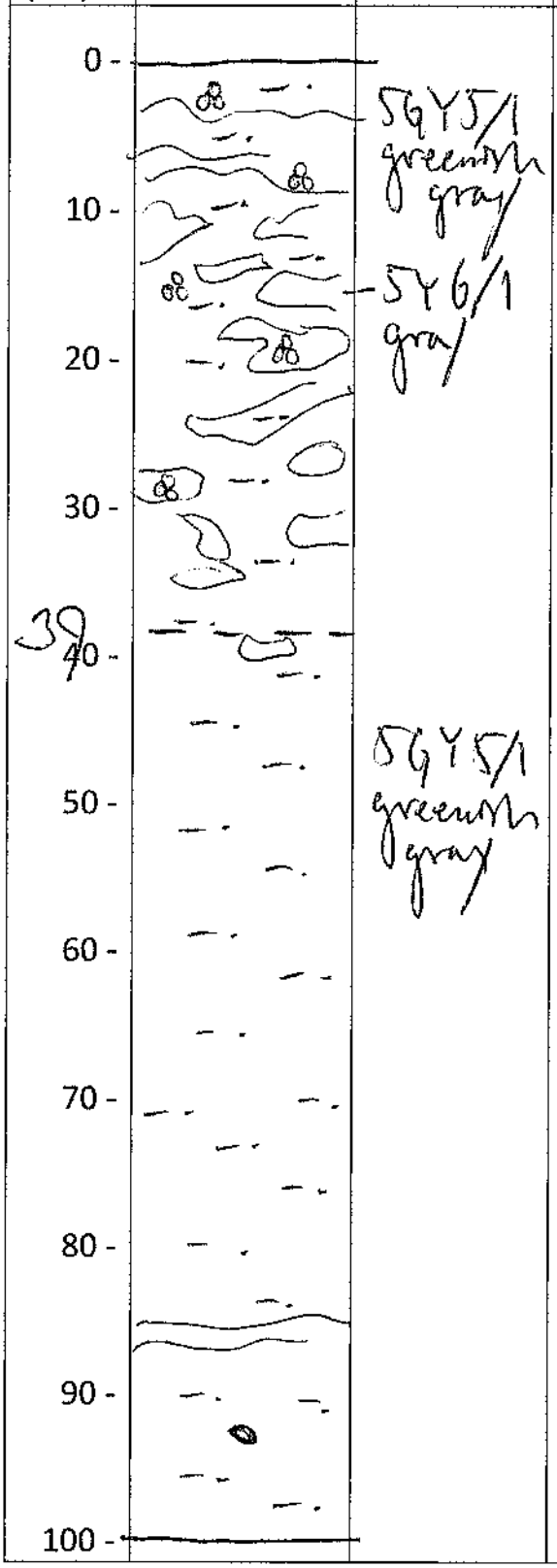
0-100 cm: Mottled to homogeneous greenish gray and gray silty clay with occasional foraminifera. Distinctly mottled with lighter gray patches against greenish gray background from 13-34 cm and from 67 to 87 cm.
Diffuse gray bands, vertically and obliquely crossing sedimentary structures from 10-34 cm, and subhorizontal bands from 44-52 cm
Open or partially filled burrows 0.5 cm Ø at 16, 25 65 cm.
Backfilled subhorizontal burrows 0.5 cm Ø at 50-53 and 59-60 cm, the last with open end.

SO242/1 gravity core description

536-636 cm

Core: SO 242-1 123 GC6	Section: 600-700 cm
Date: 21.08.2015	Described by: HJS

General remarks:

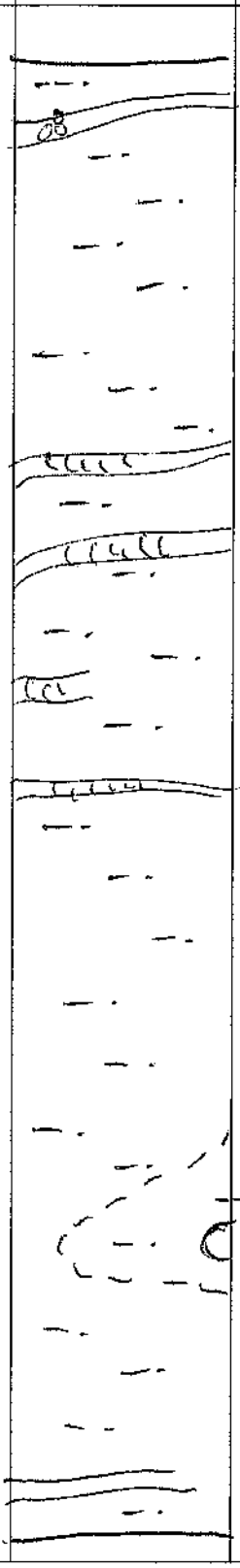


SO242/1 gravity core description

636-736 cm

Core: SO242-1 123 GC6	Section: 700-800 cm
Date: 21-08-2015	Described by: HJS

General remarks:

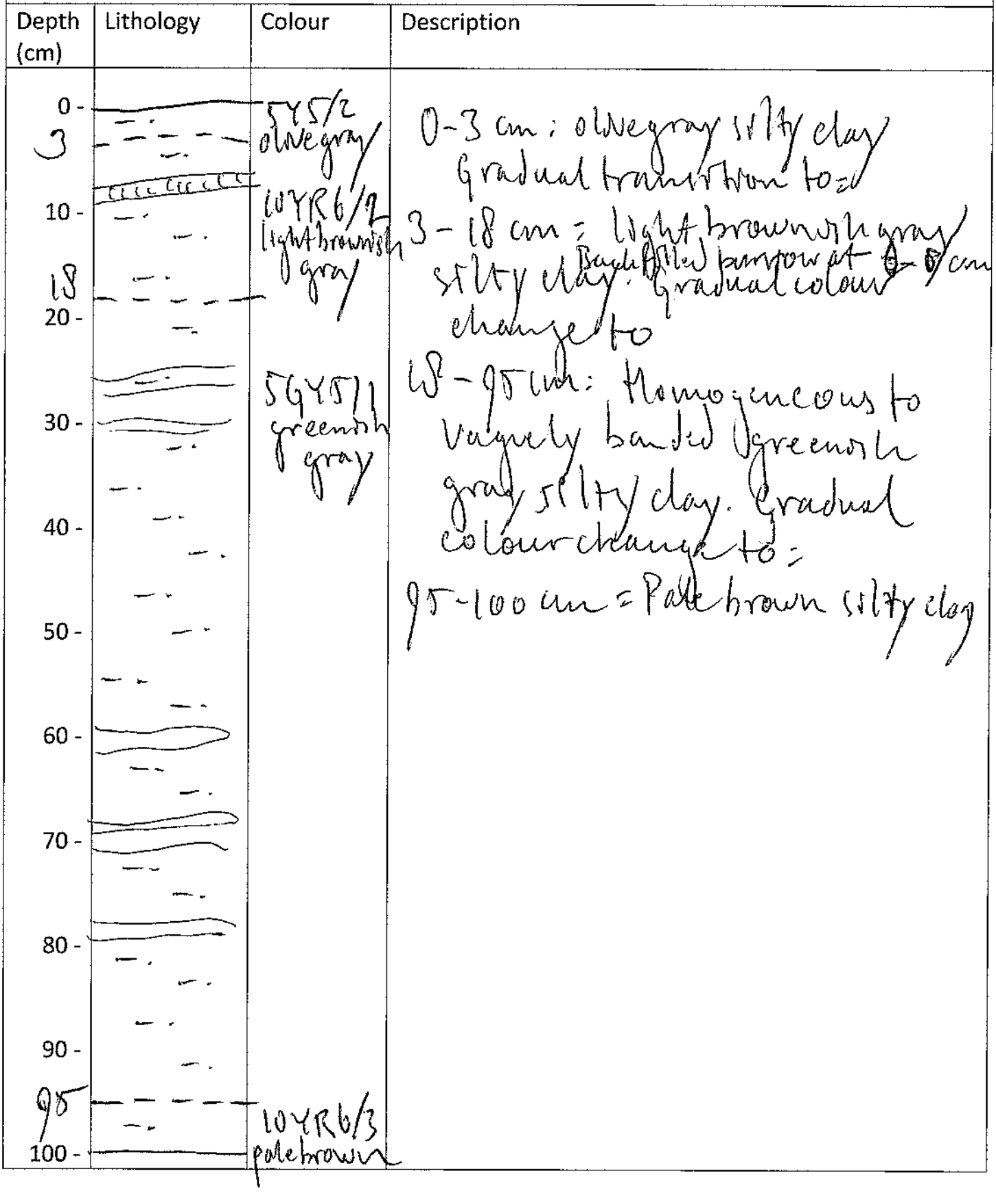
Depth (cm)	Lithology	Colour	Description
0 - 100		5GY5/1 greenish gray; 5Y5/1 gray; 2.5Y5/4 light olive brown	0-100 cm: Homogeneous to vaguely cloudy, greenish gray to gray silty clay. Backfilled subhorizontal burrows 0.5-1 cm ø at 28-30, 33-35, 42, 49 cm. Light olive brown patch with diffuse boundary at 73-84 cm, around small 1 cm ø Mn nodule at 81 cm (nodule in sampling half of core)

SO242/1 gravity core description

736-836 cm

Core: SO242-1 123 GC 6	Section: 800-900 cm
Date: 21-08-2015	Described by: HJS

General remarks:

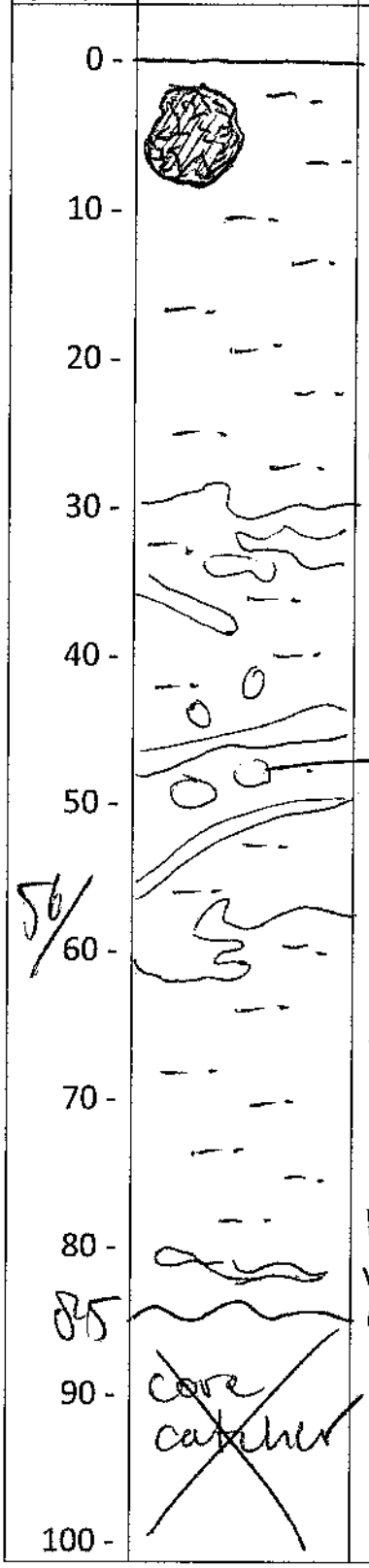


SO242/1 gravity core description

836-921 cm

Core: SO 242-1 123 GK 6	Section: 900 - 1000 cm
Date: 21-08-2015	Described by: HJS

General remarks:



Depth (cm)	Lithology	Colour	Description
0 - 30		10YR 6/3 pale brown	0 - 30 cm: Pale brown homogeneous to vaguely cloudy silty clay. Black round patch ~ 5 cm Ø of granular partially disintegrated Mn nodule at 2-7 cm. Irregular boundary to:
30 - 56/60		10YR4/3 dark brown; 10YR6/4 light yell. brown	30 - 56/60 cm: Mottled to cloudy dark brown and light yellowish brown silty clay. Irregular distinct colour boundary to:
56/60 - 85		10YR6/4 light yell. brown; 10YR5/4 yellowish brown	56/60 - 85 cm: light yellowish brown to yellowish brown silty clay. Dark brown streaks at 82 cm.
85 - 100	core catcher		

SO242/1 gravity core description

0-50 cm

Core: SO242-1 13 2 GC 7	Section: 0 - 100 cm
Date: 22-08-2015	Described by: HDS

General remarks: Top ~ 10 cm of soft watery brown sediment slumped out during core handling on deck

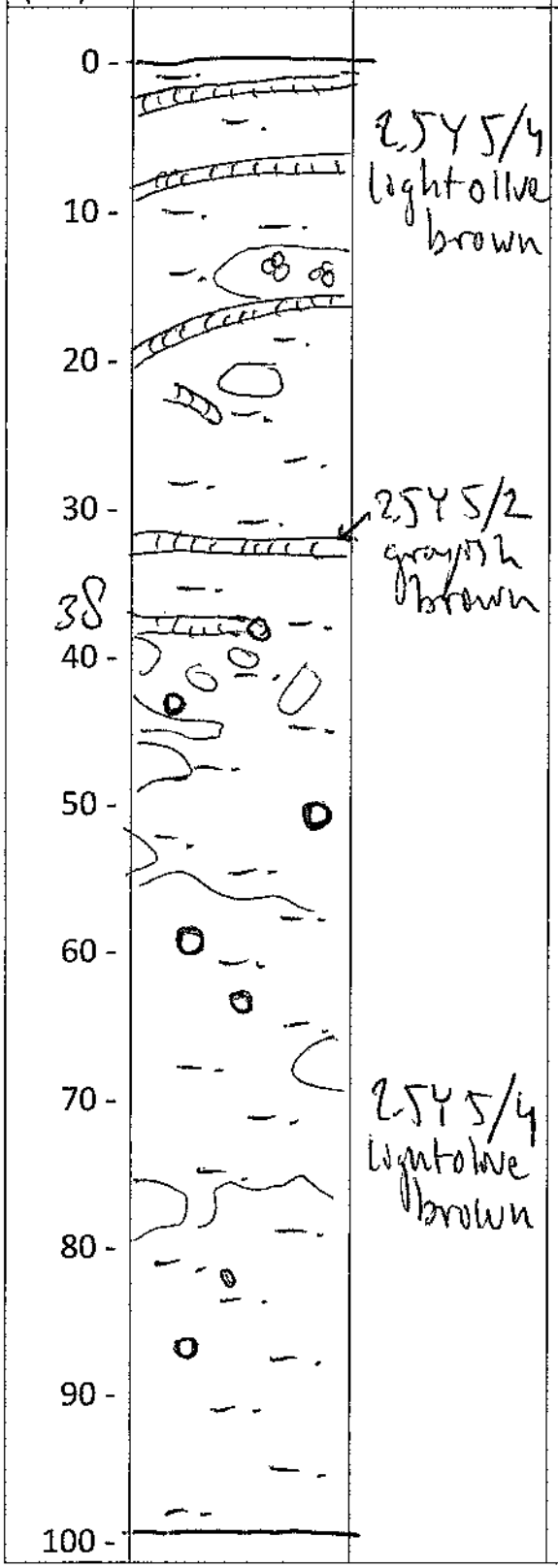
Depth (cm)	Lithology	Colour	Description
0 -	void		
10 -		10YR 3/2 Very dark grayish brown	10-17cm: Homogeneous soft very dark grayish brown silty clay
17			
20 -			17-25cm: Mottled soft very dark grayish brown and grayish brown silty clay Gradual transition to:
30 -		2.5Y 5/2 grayish brown	25-50cm: Homogeneous to vaguely mottled silty clay with foraminifera. Open or partially filled burrows 0.5cm ø at 28, 32 cm.
40 -			
50 -			
60 -			
70 -			
80 -			
90 -			
100 -			

SO242/1 gravity core description

50 - 150cm

Core: SO242-1 133GC7	Section: 100-200 cm
Date: 22-08-2015	Described by: HJS

General remarks:



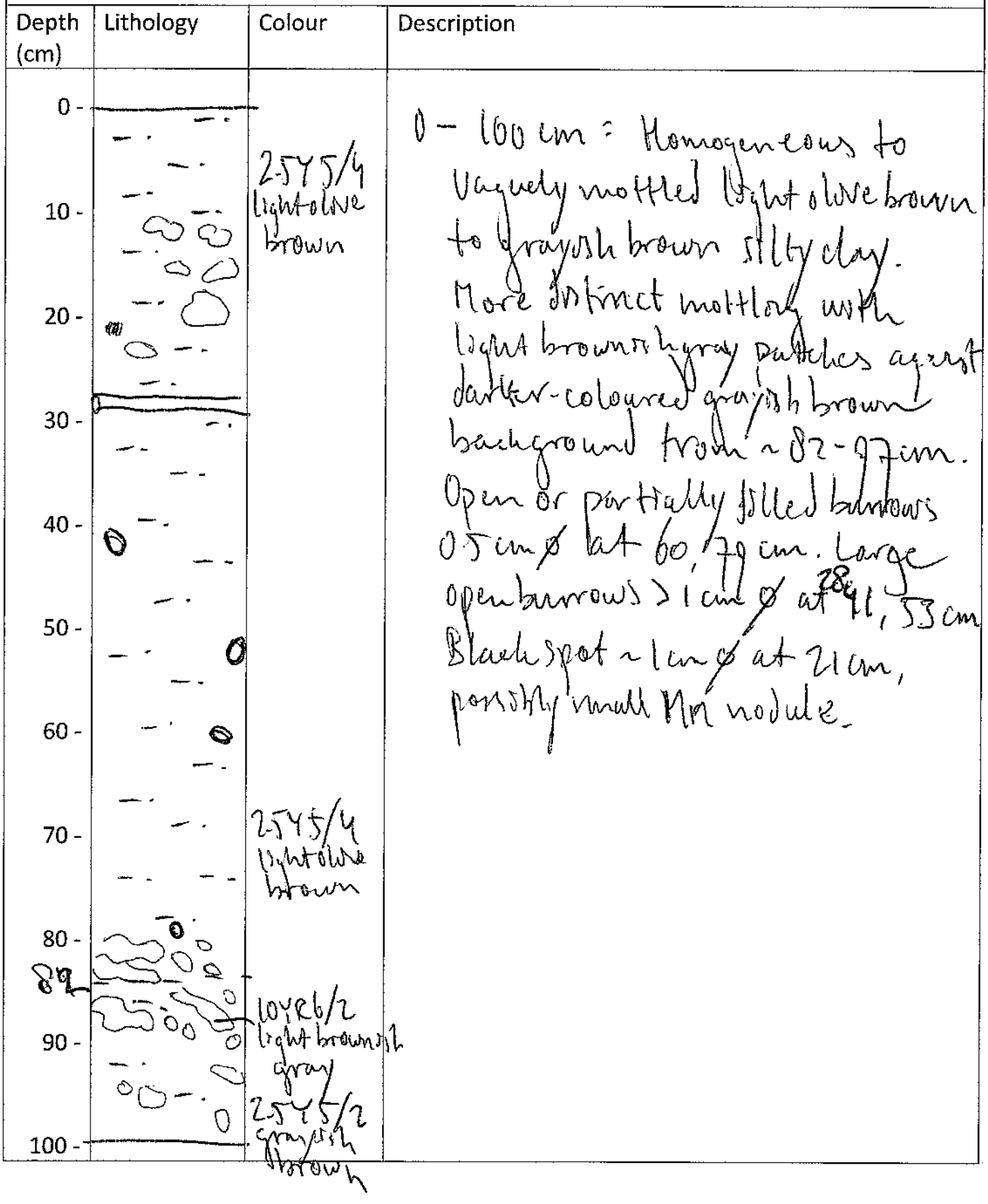
0 - 100 cm: Homogeneous to vaguely mottled light olive brown silty clay with occasional foraminifera
From 38 cm down slightly more mottled and slightly darker.
Open or partially filled burrows 0.5 cm Ø at 43, 62, 83, 88 cm,
large open burrows 1 cm Ø at 51, 59 cm, with a few 3 mm-long fecal pellets.
Backfilled subhorizontal burrows at 2, 8-9, 17-20, 33, 38 cm

SO242/1 gravity core description

150-250cm

Core: SO242-1 132 GC 7	Section: 200-300 cm
Date: 22-08-2015	Described by: HJS

General remarks:

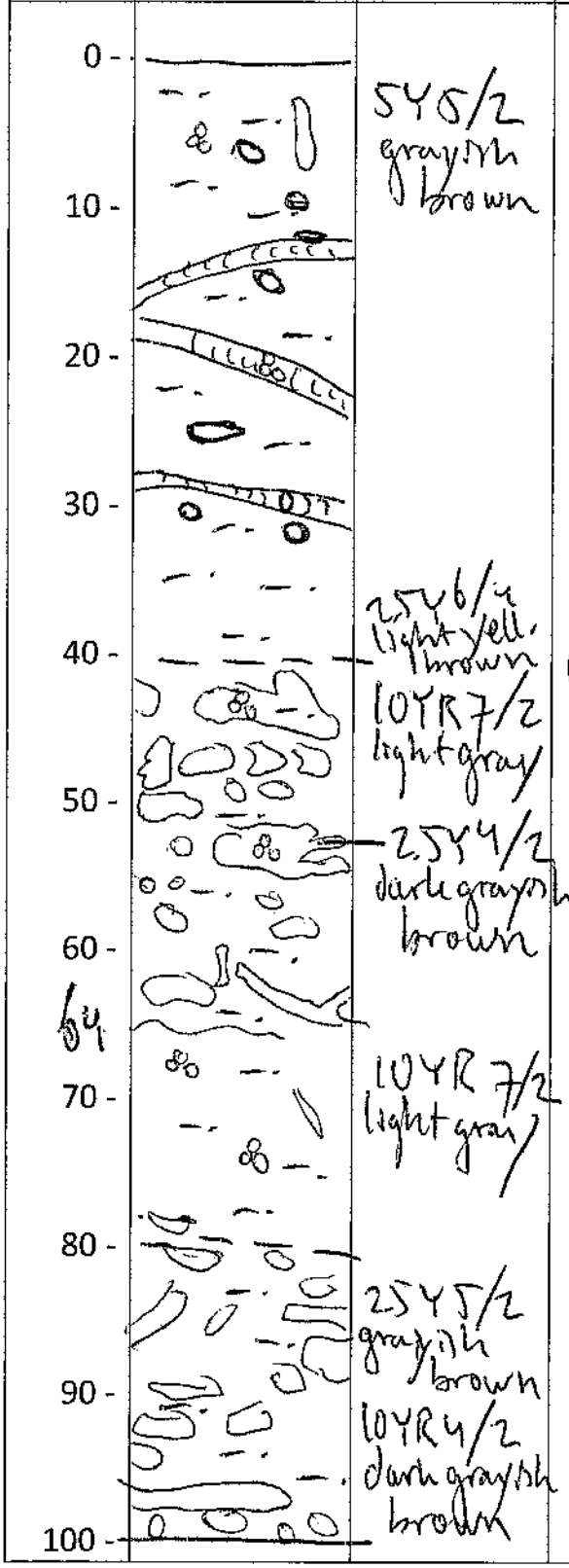


SO242/1 gravity core description

250-350 cm

Core: SO242-1 132 GC 7	Section: 300-400 cm
Date: 22-08-2015	Described by: HJS

General remarks:



0-40 cm = Vaguely mottled) grayish brown silty clay with occasional foraminifera, in lower part gradingy to light yellowish brown.
Open burrows 0.5-1 cm ø at 6, 10, 12, 14, 25, 30, 31 cm.
Backfilled subhorizontal burrows at 12-14, 18-22, 28-30 cm.
Gradual transition to:

40-64 cm: Distinctly mottled light gray and dark grayish brown silty clay with some foraminifera.

64-80 cm = Mottled) light gray silty clay.

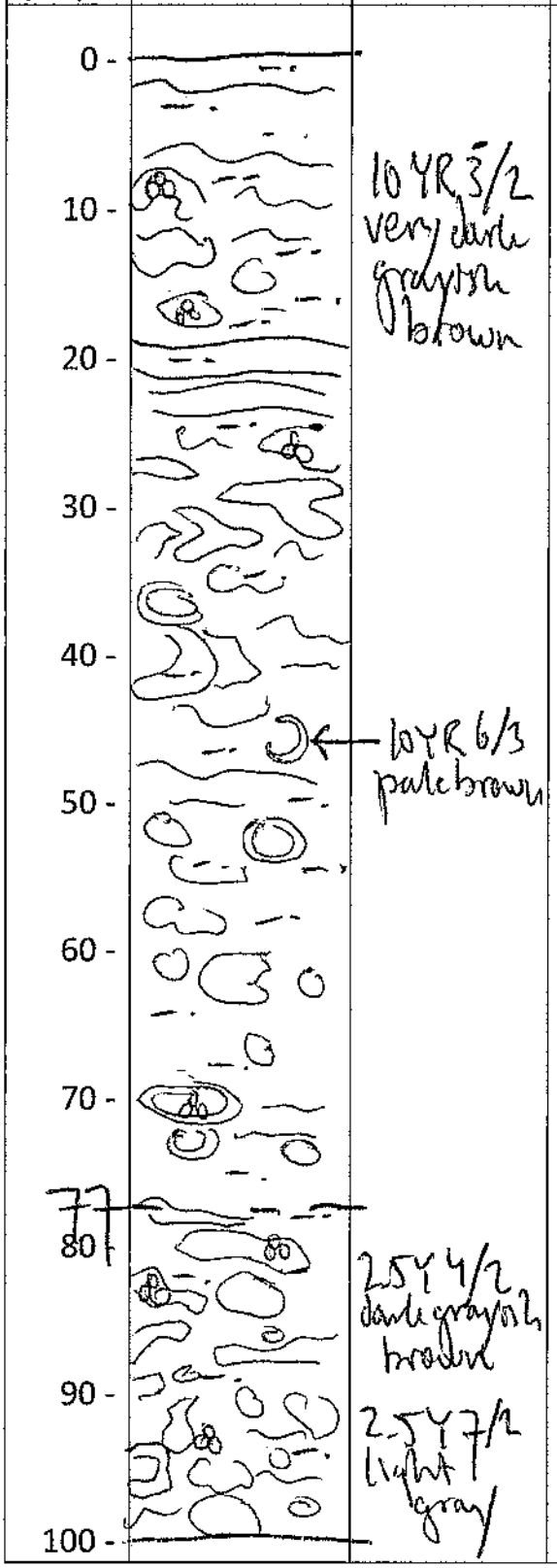
80-100 cm = Distinctly mottled grayish brown and dark grayish brown silty clay

SO242/1 gravity core description

350-450 cm

Core: SO242-1 138 GC 7	Section: 400-500 cm
Date: 22-08-2015	Described by: HdS

General remarks:



0-77 cm = Mottled to cloudy very dark grayish brown silty clay with a few lighter coloured patches or rings ~1-2cm Ø. Occasional foraminifera in lighter patches. Gradual transition to:

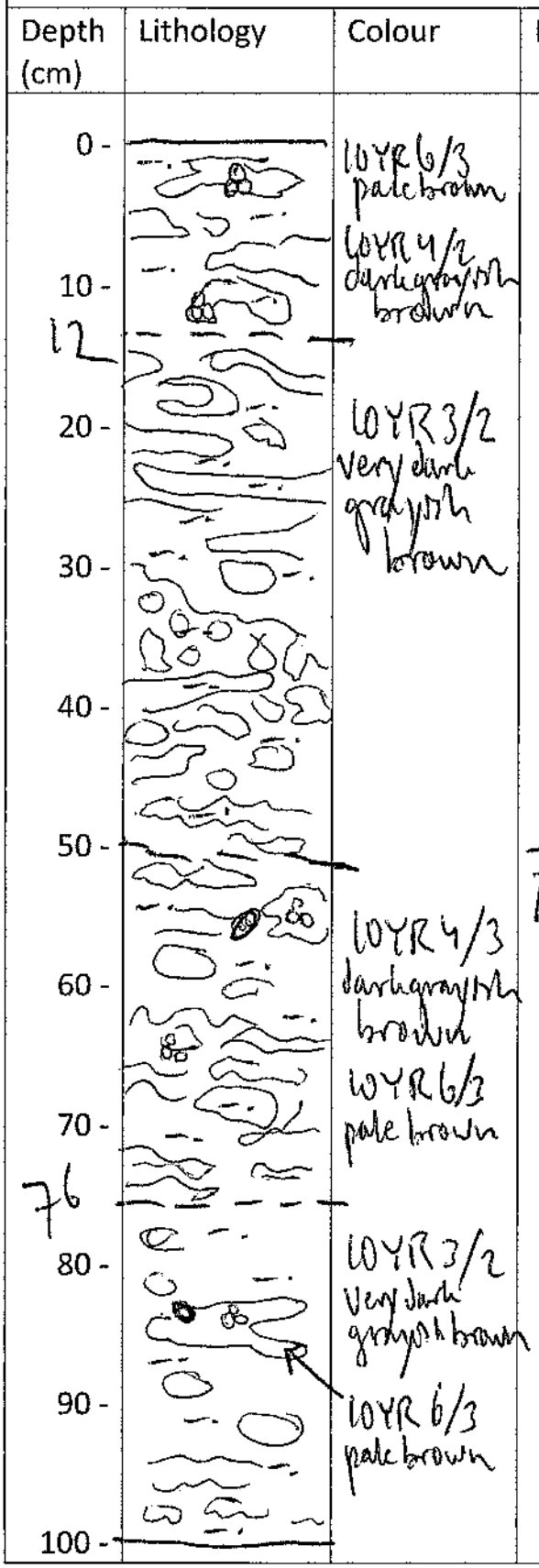
77-100 cm: Mottled to cloudy light gray and dark grayish brown silty clay with occational foraminifera

SO242/1 gravity core description

450-550 cm

Core: SO242-1 132 GC7	Section: 500-600 cm
Date: 22-08-2015	Described by: HDS

General remarks:



Description

0-12cm: Mottled pale brown and dark grayish brown silty clay with occasional foraminifera

12-50cm: Mottled very dark grayish brown silty clay. Gradual transition to:

50-76cm: Distinctly mottled dark grayish brown and pale brown silty clay with occasional foraminifera. Partially filled burrow 0.5 cm ø with fecal pellets at 55 cm.

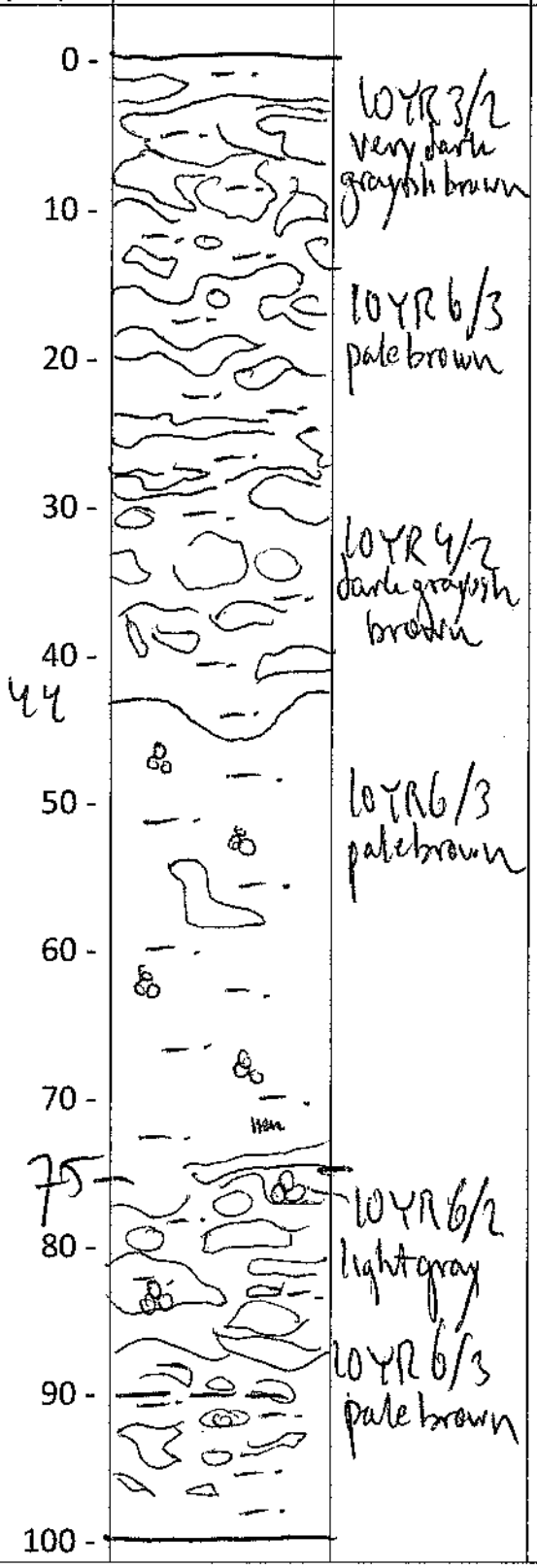
76-100cm: Distinctly mottled to banded very dark grayish brown and pale brown silty clay, mostly darker shades from 76 to 93 cm, then slightly lighter to 100 cm.

SO242/1 gravity core description

550-650cm

Core: SO242-1 132 GC7	Section: 600-700 cm
Date: 22-08-2015	Described by: HJS

General remarks:



Description

0 - 44 cm: Mottled to banded dark grayish brown and pale brown silty clay. Lighter colours prevail from 16-26 cm, mostly darker colours from 26 - 44 cm.

44 - 75 cm: Homogeneous to vaguely mottled pale brown silty clay with foraminifera. Black Mn oxide spot at 72 cm. Gradual transition to:

75 - 90 cm: Distinctly mottled light gray and pale brown silty clay with foraminifera. Gradual transition to:

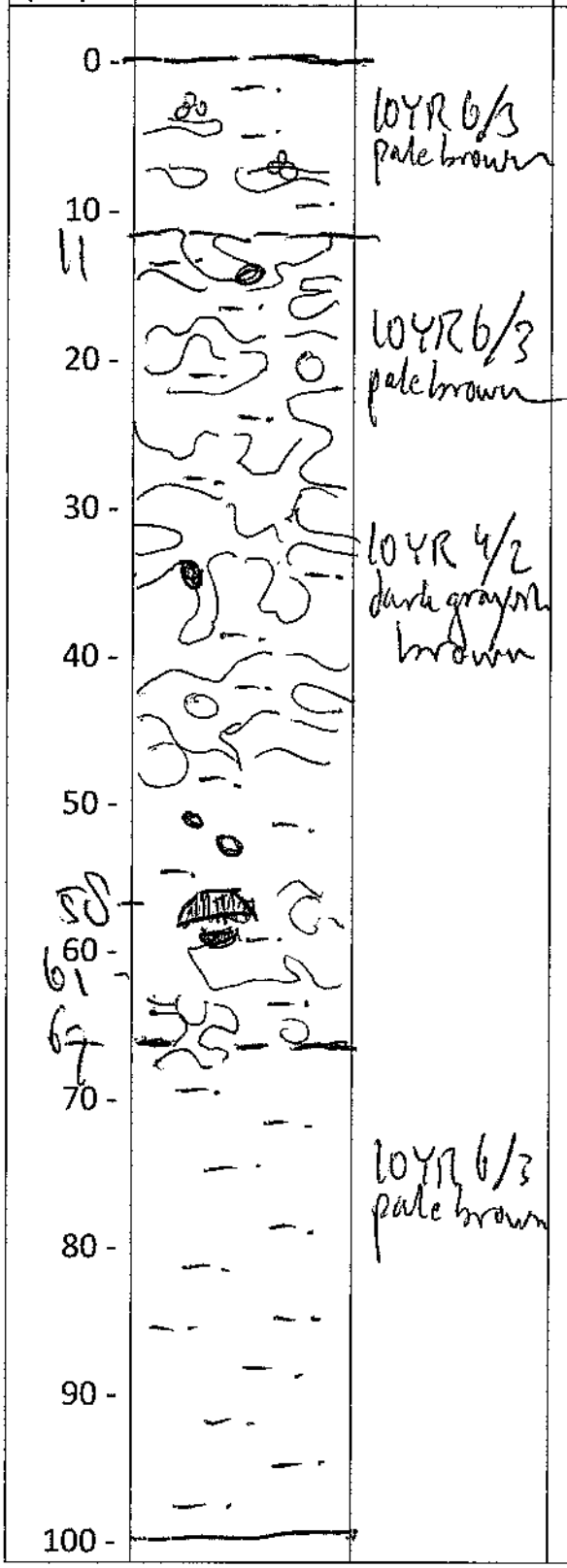
90 - 100 cm: Mottled pale brown and light gray silty clay

SO242/1 gravity core description

650-750 cm

Core: SO 242-1 132 GC 7	Section: ~~700~~ 650-~~800~~ 750
Date: 22-08-2015	Described by: HJS

General remarks:



0-11cm: Mottled pale brown silty clay with occasional forams

11-67cm: Coarsely mottled pale brown and dark grayish brown silty clay. Black solid Mn nodule at 58-61cm. Open or partially filled burrows 0.5cm Ø at 12, 35, 51 cm. Darker mottles fading out to boundary with:

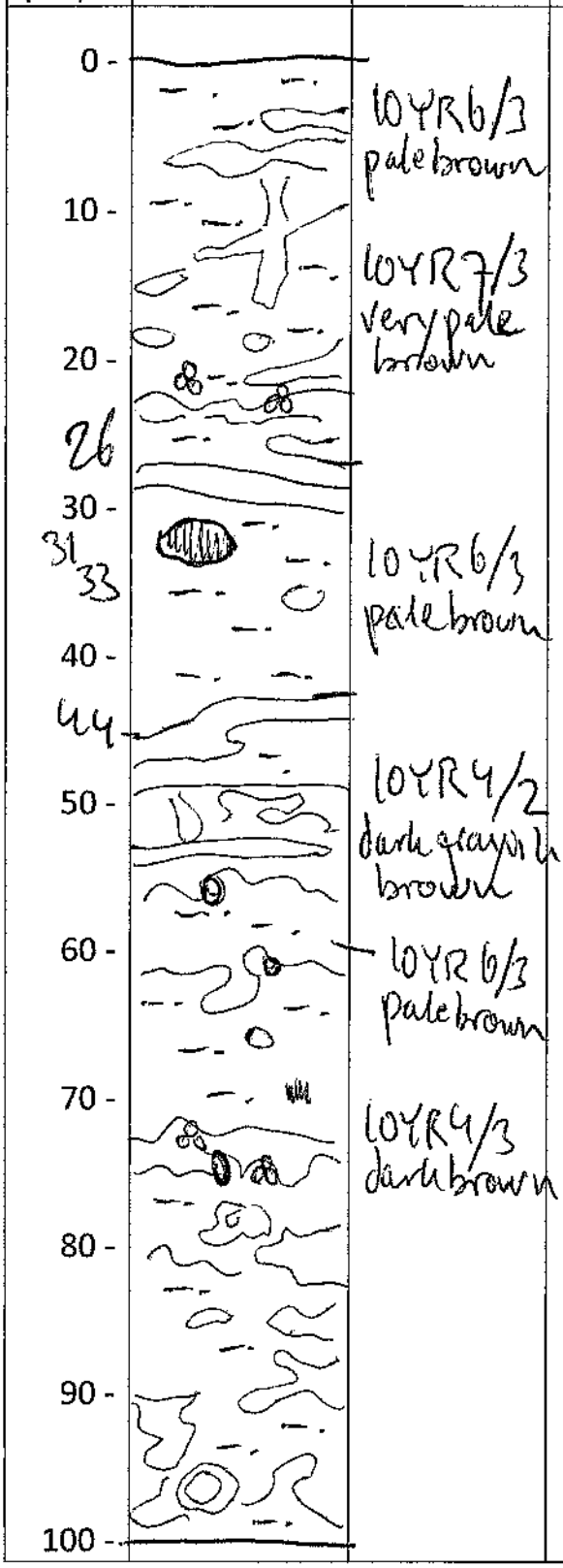
67-100 cm: Homogeneous pale brown silty clay

SO242/1 gravity core description

750-850 cm

Core: SO 242-1 132 GC7	Section: 800-900 cm
Date: 27-08-2015	Described by: HJS

General remarks:



Description

0-26 cm: Vaguely mottled pale brown and very pale brown silty clay with occasional forams Gradual transition to:

26-44 cm: Homogeneous pale brown silty clay. Black solid Mn nodule at 31-33 cm

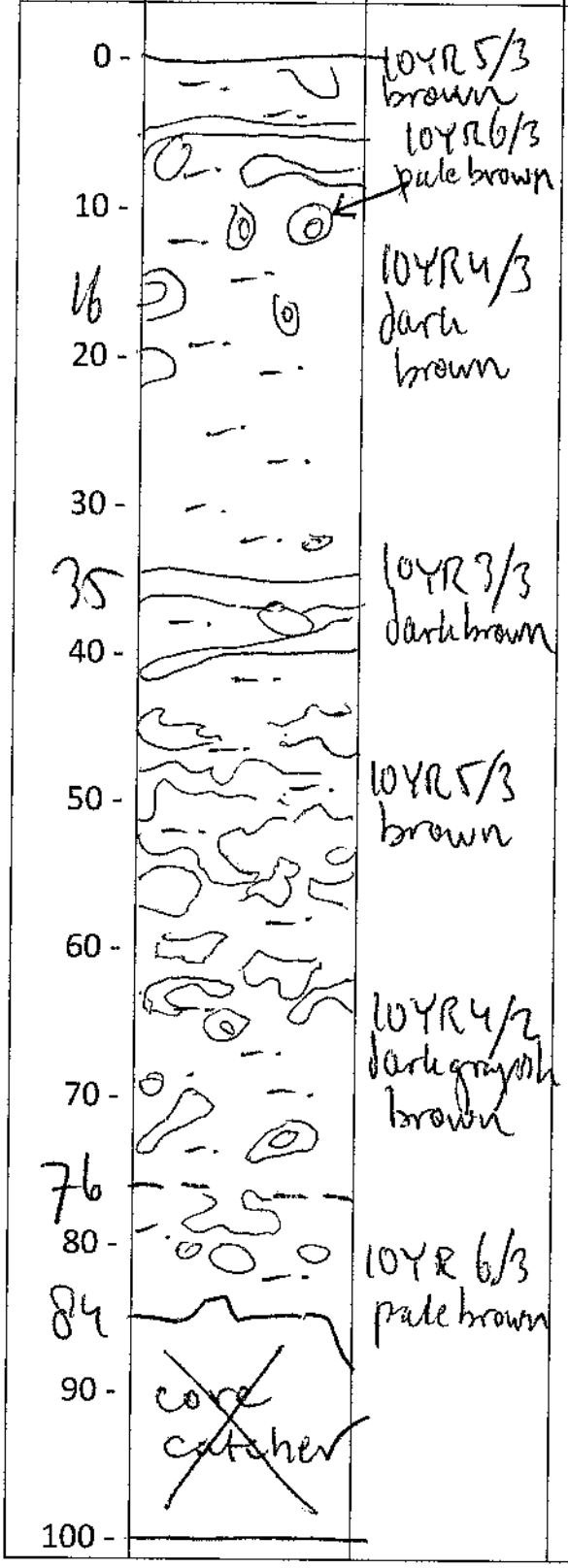
44-100 cm: Mottled to cloudy dark grayish brown and dark brown and pale brown silty clay with occasional foraminifera Partially filled burrows 0.5 cm Ø at 57, 60, 75 cm

SO242/1 gravity core description

850-936 cm

Core: SO242-1 132 GC7	Section: 900-1000 cm
Date: 22-08-2015	Described by: HJS

General remarks:



Description

0-76 cm: Mottled, homogeneous and cloudy brown silty clay, different shades of brown and dark brown, with a few round to oval lighter brown patches 1-2 cm Ø, often with darker core = resembling "hazelnut" as seen on other cores. Isolated mottles 0-16 cm, mostly homogeneous 16-35 cm, then more cloudy 35-76 cm. Gradual transition to:

76-84 cm: Distinctly mottled pale brown and dark grayish brown silty clay

9.6 OFOP button file

List of megafaunal descriptors used in the video annotation of the DISCOL area, as buttons in the Ocean Floor Observation Protocol software. You can copy and paste the table into a simple text editor and use it in OFOP.

# Button names	Entry ID	Button ID
Fish	23	1
Ipnops	10043	2
Sponge	29	3
Coral	25	4
Polychete	10004	5
Asteroid	101	6
Crinoid	102	7
Holothurian	107	8
Echinoid	106	9
Ophiuroid	112	10
Probeebei	20003	11
Shrimp	105	12
Unknown	6666	13
Unknown Mn	1013	14
Unknown S	1014	15
? Interesting	10	23
#----------		
On Plough	-1	51
Strong Pl.	9	16
Intermediate Pl.	10001	17
Weak Pl.	10002	18
#----------		
Outside Plough	-1	52
No plough	20004	19
Unclear Plough	20005	20
#----------		
Mn nodule cover	-1	55
No nodules	3001	25
Mid-low	3002	26
High	3003	27
#----------		
Litter	-1	54
Plastic	661	28
Metal	662	29
Other/unknown	663	30
#----------		
___PORIFERA on sediment		
_____	-1	101
-Non-stalked--------	-1	102
Cup s/ns	10070	103
Funnel s/ns	10071	104
Disk s/ns	10072	105
Massive s/ns	10073	106
Tubular s/ns	10074	107
Round s/ns	10075	108
Laminated s/ns	10085	109
-Stalked----------	-1	110
Porifera s/s	10303	111
Cup s/s	10076	112

Funnel s/s	10078	113
Disk s/s	10082	114
Tubular s/s	10083	115
Round s/s	10084	116
	-1	117
__ undet. STALKs ____	-1	201
	-1	202
Stalk	10305	203
Stalk sed	10305	204
Stalk Mn	10306	205
Alive stalk	6701	206
Stalk A/sed	6702	207
Stalk A/Mn	6703	208
Dead stalk	6704	209
Stalk D/sed	6705	210
Stalk D/Mn	6706	211
	-1	212
___CRUSTACEA _____	-1	213
Cirripedia	10040	214
Galatheidae	10041	215
Picnogonid	10042	216
Parapaguridae	20003	217
Munnopsidae	1080	218
Isopoda	1091	219
	-1	220
___FISH_____	-1	221
Fish	23	222
Ipnops	10043	223
Anguiliforme	10044	224
Bathysaurus	10045	225
___CNIDARIA _____	-1	301
---Hydrozoa---------	3013	302
Corymorphidae	10030	303
	-1	304
---Anthozoa----------	-1	305
Stalk Cnidaria s	10306	306
Stalk Cnidaria Mn	10307	307
-Actiniaria	10031	308
Actinian on sed	3001	309
Actinian on Mn	3002	310
-Alcyonacea	10032	311
Alcyonacea on sed	3003	312
Alcyonacea on Mn	3004	313
-Antipatharia	10033	314
Antipatharia on sed	3005	315
Antipatharia on Mn	3006	316
-Ceriantharia	10034	317
Cerianthid on sed	3007	318
Cerianthid on Mn	3008	319
-Corallimorpharia	10035	320
Corallimorph on sed	3009	321
Corallimorph on Mn	3010	322
-Pennatulacea	10036	323
Umbelulla sp	6710	324
Umbellula on sed	3011	325
Umbellula on Mn	3012	326

Pennat. on sed	6711	327
Pennat. on Mn	6712	328
	-1	329
---Sciphozoa---------	-1	330
Sciphozoan	6668	331
__PORIFERA on Mn _____	-1	401
-Non-stalked--------	-1	402
Cup Mn/ns	10020	403
Funnel Mn/ns	10021	404
Disk Mn/ns	10022	405
Massive Mn/ns	10023	406
Tubular Mn/ns	10024	407
Round Mn/ns	10025	408
Laminated Mn/ns	10029	409
-Stalked---------	-1	410
Porifera Mn/s	10304	411
Cup Mn/s	10085	412
Funnel Mn/s	10086	413
Disk Mn/s	10087	414
Tubular Mn/s	10088	415
Round Mn/s	10089	416
	-1	417
____ FORAMINIFERA _____	-1	418
Plate-like on nodule	10010	419
Plate-like	10011	420
Xenophyophore	10012	421
Tubular	10013	422
___ECHINODERMATA _____	-1	501
	-1	502
____Crinoidea_____	-1	503
Stalked	10050	504
Non-stalked	10051	505
	-1	506
____Asteroidea_____	1090	507
Brisingida (e.g. Freyella)	10052	508
Paxillosida ("normal")	10053	509
Vellatida (vellum btw arms)	1089	510
	-1	511
____Echinoidea_____	-1	512
Long-spines	10054	513
Flat	10055	514
Round	10056	515
Pineapple-like pattern	10057	516
	-1	517
____Ophiuroidea_____	-1	518
Ophiuroid on stalks	10058	519
Ophiuroid on sediment	10059	520
Ophiuroid on nodule	10080	521
___Holothuroidea____	-1	601
Spiny	10060	602
Smooth	10061	603
Psychropotidae	10062	604
Elpidiidae	10063	605
Amperima	10064	606

Peniagone mtp	10065	607
Scotoplanes	10066	608
Swimming elpidid	1010	609
Synallactidae	1092	610
Synallactes pink	10067	611
Synallactes white	10068	612
Deima sp	10069	613
Pseudostichopus	1093	614
Benthodytes	1094	615
Benthoturia	1095	616
Paleopatides	1096	617
Orphnurgus	1097	618
Mesothuria	1098	619
Pelagothuria	1099	620
Bizarre(green)mtp	2671	621
Laetmogonidae	1088	622

9.7 Amphipod morphotypes

List of amphipod morphotypes sorted on board during this cruise.

JPIO SO242-1 DISCOL AMPHIPOD DATA					
STATION No.	**DATE**	**GEAR USED**	**PRELIMINARY MORPHOLOGICAL DESCRIPTION**	**~ No. of SPECIMENS**	**RBINS VIAL No.**
242-1_8-1	01.08.15	Amphi-Trap	Crested Eurythenes	45	-
242-1_8-1	01.08.15	Amphi-Trap	Non-crested Eurythenes	50	-
242-1_8-1	01.08.15	Amphi-Trap	Red Eurythenes	2	-
242-1_8-1	01.08.15	Amphi-Trap	Bulk of unknown/strange specimen	8	1
242-1_8-1	01.08.15	Amphi-Trap	LYSIA. Large white eye	2	2
242-1_8-1	01.08.15	Amphi-Trap	LYSIA. Small white eye	3	3
242-1_8-1	01.08.15	Amphi-Trap	sp. Unknown	4	4
242-1_8-1	01.08.15	Amphi-Trap	sp. Small white eye	8	5
242-1_8-1	01.08.15	Amphi-Trap	sp. Pink w/small red eye	3	6
242-1_8-1	01.08.15	Amphi-Trap	cf. Hirondellea	11	7
242-1_8-1	01.08.15	Amphi-Trap	LYSIA. sp.	3	8
242-1_8-1	01.08.15	Amphi-Trap	LYSIA. sp. Small white eye	70	9
242-1_8-1	01.08.15	Amphi-Trap	Long bodied w/long antenna	19	10
242-1_8-1	01.08.15	Amphi-Trap	cf. Hirondellea	50	11
242-1_8-1	01.08.15	Amphi-Trap	Unknown/strange specimen	1	12
242-1_8-1	01.08.15	Amphi-Trap	Bulk of small amphis	5000	-
242-1_8-1	01.08.15	Ostracod Trap	Bulk of small ostracod + amphis	-	-
242-1_8-1	01.08.15	Ostracod Trap	Bulk of small ostracod + amphis	-	-
242-1_8-1	01.08.15	Plankton net	Bulk of planktonic material (depth unknown)	-	-
			TOTAL SPECIMENS DEPLOYMENT 1	**5279**	
242-1_30-1	02.08.15	Amphi-Trap	Elongated body w/red eyes	1	1
242-1_30-1	02.08.15	Amphi-Trap	Elongated body w/white eyes	18	2
242-1_30-1	02.08.15	Amphi-Trap	Deep purple small amphis	110	3
242-1_30-1	02.08.15	Amphi-Trap	Elongated body w/white eyes + short antenna	30	4
242-1_30-1	02.08.15	Amphi-Trap	Elongated body w/white eyes + long antenna	35	5
242-1_30-1	02.08.15	Amphi-Trap	Bulky amphis w/large white eyes	4	6
242-1_30-1	02.08.15	Amphi-Trap	LYSIA. carcass (eaten by smaller amphis)	1	7
242-1_30-1	02.08.15	Amphi-Trap	Eurythenes crested carcass	3	8
242-1_30-1	02.08.15	Amphi-Trap	Eurythenes sp. carcass	1	9
242-1_30-1	02.08.15	Amphi-Trap	Bulky amphis w/ small white eyes	140	10 & 11
242-1_30-1	02.08.15	Amphi-Trap	Yellow unconventionally shaped amphi	1	13
242-1_30-1	02.08.15	Amphi-Trap	Eurythenes crested	30	15
242-1_30-1	02.08.15	Amphi-Trap	Eurythenes non-crested	25	16
242-1_30-1	02.08.15	Ostracod Trap	Bulk of small ostracod + amphis	-	-
242-1_30-1	02.08.15	Plankton net	Bulk of planktonic material (depth unknown)	-	17
242-1_30-1	02.08.15	AUV 3 - Station 242-1_25-1	Ostracods (depth unknown) (Podocopida?)	30	14
			TOTAL SPECIMENS DEPLOYMENT 2	**429**	

242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Elongated body w/long antenna	10	1
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Yellow unconventionally shaped amphi	4	2
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Bulky amphis w/large white eyes	7	4
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Large eyes w/long antenna	1	4
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	cf. Hirondellea	35	5
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Stegocephalidae	10	6
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Elongated body w/long antenna	14	7
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Elongated body w/short antenna	50	8
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Bulky LYSIA.	120	9 & 10
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Eurythenes non-crested	60	11
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Eurythenes crested	60	12
242-1_55-1 (short deployment)	07.08.15	Amphi-Trap	Bulk of small amphis	15000	13, 14 & 15
242-1_55-1 (short deployment)	07.08.15	Ostracod Trap	Standard bulk material of ostracods and amphis (4 lower traps)	-	-
242-1_55-1 (short deployment)	07.08.15	Ostracod Trap	Extra 2 traps attached 50cm above standard traps	-	-
242-1_55-1 (short deployment)	07.08.15	Plankton net	Bulk of planktonic material (depth unknown)	-	-
			TOTAL SPECIMENS DEPLOYMENT 3	**15371**	
242-1_68-1	14.08.15	Amphi-Trap	Thin bodied w/long antenna	3	1
242-1_68-1	14.08.15	Amphi-Trap	Thin bodied w/short antenna	15	2
242-1_68-1	14.08.15	Amphi-Trap	cf. Hirondellea	11	3
242-1_68-1	14.08.15	Amphi-Trap	Bulky amphis w/short thick antenna	16	4
242-1_68-1	14.08.15	Amphi-Trap	Bulky LYSIA. w/small eyes & thin antenna	60	5
242-1_68-1	14.08.15	Amphi-Trap	Yellow unconventionally shaped amphi	5	6
242-1_68-1	14.08.15	Amphi-Trap	Eurythenes non-crested	20	7
242-1_68-1	14.08.15	Amphi-Trap	Eurythenes crested	35	8
242-1_68-1	14.08.15	Amphi-Trap	Bulk of small amphis	3000	9 &10
242-1_68-1	14.08.15	Ostracod Trap	Standard bulk material of ostracods and amphis (4 lower traps)	-	-
242-1_68-1	14.08.15	Ostracod Trap	Extra 2 traps attached 50cm above standard traps	-	-
242-1_68-1	14.08.15	Plankton net	Bulk of planktonic material (depth unknown)	-	11
			TOTAL SPECIMENS DEPLOYMENT 4	**3165**	

9.8 DISCOL Revival

Things change with time. In 1989 navigation at sea just started to use GPS, video guided sampling was just possible, ROVs and AUVs did not exist. During SO242/1 we had it sometimes easier than the real pioneers of DISCOL, sometimes our high tech also caused sleepless nights. During the cruise colleagues from Portugal and the UK felt that we should 'honor' the real pioneers with an homage to their bravery, endurance and looking advantageous on photos. Below you see the result …

Figure 9.8.1: Our homage to the pioneers of DISCOL

Figure 9.8.2: The team during SO242/1.

… we will be back!!

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No.	Title
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4	RV CELTIC EXPLORER EUROFLEETS Cruise Report, CE12010 – ECO2@NorthSea, 20.07. – 06.08.2012, Bremerhaven – Hamburg, Eds.: P. Linke et al., 65 pp, DOI: 10.3289/GEOMAR_REP_NS_4_2012
5	RV PELAGIA Fahrtbericht / Cruise Report 64PE350/64PE351 – JEDDAH-TRANSECT -, 08.03. – 05.04.2012, Jeddah – Jeddah, 06.04 - 22.04.2012, Jeddah – Duba, Eds.: M. Schmidt, R. Al-Farawati, A. Al-Aidaroos, B. Kürten and the shipboard scientific party, 154 pp, DOI: 10.3289/GEOMAR_REP_NS_5_2013
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11	RV SONNE Fahrtbericht / Cruise Report SO227 TAIFLUX, 02.04. – 02.05.2013, Kaohsiung – Kaohsiung (Taiwan), Christian Berndt, 105 pp, DOI: 10.3289/GEOMAR_REP_NS_11_2013

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13	KIEL276 Time Series Data from Moored Current Meters. Madeira Abyssal Plain, 33°N, 22°W, 5285 m water depth, March 1980 – April 2011. Background Information and Data Compilation. Eds.: Thomas J. Müller and Joanna J. Waniek, 239 pp, DOI: 10.3289/GEOMAR_REP_NS_13_2013
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26	RV SONNE Fahrtbericht / Cruise Report SO242-1, JPI OCEANS Ecological Aspects of Deep-Sea Mining, DISCOL Revisited, Guayaquil - Guayaquil (Equador), 29.07.-25.08.2015, Ed.: Jens Greinert, 290 pp, DOI: 10.3289/GEOMAR_REP_NS_26_2015

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